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This report is intended to provide training material for use by the Leadership and Organizational Effectiveness School and the Naval Postgraduate School to assist in training consultants in the redesign of organizational systems using the sociotechnical design method. It presents an overview of the sociotechnical system approach to organization design and redesign aimed at productivity improvement. Specific application is made to military settings. The report presents the theory, principles, and methods of sociotechnical system analysis and design, prerequisites for application of this technology and a strategy vital to successful implementation of it in military settings. A case study of an organization redesign project in a Navy ship repair organization is used to illustrate the concepts. A list of related readings is provided. Discussion of how to institutionalize a new design and transfer it to various organizational settings concludes the report.

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ORGANIZATION REDESIGN FOR PRODUCTIVITY IMPROVEMENT: METHOD AND CASE STUDY

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FOREWORD

Two years ago the concept of work teams was introduced in the Pump Repair Shop at the Navy Shore Intermediate Maintenance Activity (SIMA), San Diego, to improve productivity. Although the new work organization was successful in increasing output, the commanding officer wanted additional evaluation by the Navy Personnel Research and Development Center (NAVPERSRANDCEN) to see whether the work organization could be further improved, to determine how it could be maintained through changes in leadership, and assess the feasibility of extending the concept to other SIMA shops.

NAVPERSRANDCEN planned the study of the pump repair system in three phrases: Phase I, funded by SIMA (R6591884WR00042), focused on analysis of the system and resulted in recommended changes to improve it. These changes were implemented in Phase II with Chief of Naval Operations Studies and Analysis funding (N0001484WR35128) and later reimbursible funding (N0002285WRHH510) provided by NMPC-62. This report is a byproduct of the second phase, summarizing the sociotechnical system design methodology used in these two phases. Phase III, as yet unfunded, will comprise a long-term evaluation of the effects of the changes in the system. The cycle will be repeated and extended during FY86 by application to another repair system in SIMA, San Diego, and an afloat IMA.

Appreciation is expressed by the authors to Captain Hay and to the management and personnel of SIMA for their enthusiastic collaboration in this project.

Howard S. Eldredge
Captain, U.S. Navy
Commanding Officer

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Technical Director

SUMMARY

This report is intended to provide training material for use by the Leadership and Organizational Effectiveness School and the Naval Postgraduate School to assist in training consultants in the redesign of organizations using the sociotechnical system design method.

It presents an overview of the sociotechnical system approach to organization design and redesign aimed at productivity improvement. Specific application is made to military settings. It presents the theory, principles, and methods of sociotechnical system design, prerequisites for application of this technology and a strategy vital to successful implementation of it in military settings. A case study of an organization redesign project in a Navy ship repair organization is used to illustrate the concepts. A list of related readings is provided.

Discussion of how to institutionalize a new design and transfer it to various organizational settings concludes the report.

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PROBLEM

Navy activities are under continual pressure to improve their mission effectiveness. In response, Navy managers maintain an interest in productivity-enhancing ideas. When mission requirements change, the entire organizational structure may be under scrutiny. Under these conditions Navy commands may seek assistance in redesigning their organizational structure to maximize effectiveness or meet increased demands. The Organizational Effectiveness (OE) Centers are sources of expert assistance often approached under these conditions. Although OE consultants can bring to bear a broad repertoire of skills and knowledge in specific aspects of organizational functioning, they have lacked a comprehensive organization design technology to address the issues of productivity and mission effectiveness in military settings.

OBJECTIVES

The objectives of this report are to: (1) present the conceptual framework of sociotechnical system design in a form applicable to military settings; (2) illustrate how the technology applies to a military organization; and (3) explore change and institutionalization issues related to organization redesign in military settings.

BACKGROUND

These materials grew out of an organizational redesign project conducted at the Shore Intermediate Maintenance Activity (SIMA), San Diego. The dual mission of this organization is to provide (1) intermediate level maintenance for the fleet and (2) training of Navy personnel. The Pump Repair Shop, a part of a standard Navy organization, had experienced low productivity, high rework, and difficulty in meeting production schedules. SIMA command took action to correct the situation by charging a new branch officer with the task of improving shop performance. He accomplished this by reorganizing the shop around small work teams which were given total responsibility for the repair of assigned pumps. Productivity, adjusted for changes in manning levels, increased 40 percent. In light of this apparent success, SIMA command requested that the Navy Personnel Research and Development Center (NAVPERSRANDCEN) evaluate the team concept used in the Pump Shop, recommend ways to improve and institutionalize it and explore the possibilities of transferring the concept of a team-based organization to other shops in SIMA.

The Pump Repair Shop had several distinguishing organizational characteristics that had to be accommodated: (1) A planned turnover rate of 60 percent/year; (2) a high proportion of inexperienced replacements, resulting in a need for continuous training; (3) an environment characterized as <u>uncertain</u> (because of lack of reliable or sufficient information about pumps needing repair), <u>unstable</u> (because of rapidly changing workloads and time schedules), and <u>uncontrollable</u> (because of outside forces that determined workload); and (4) a product array (pumps) which displayed high variability in type, size, and condition. In addition, the team-based organization was anomalous within the prevailing Navy culture, raising issues regarding its long-term viability.

During the initial, analytic phase of the project the authors ascertained that the work team design in the Pump Shop was, indeed, well-suited to the environmental conditions, task demands, and personnel training requirements, as demonstrated by improved output

The technical system of an organization consists of the tools, techniques, procedures, skills, and knowledge used by members of the social system to accomplish organizational goals. Choices in technical system design at both the individual and organizational levels affect the social system by shaping the attitudes and behaviors of the individuals required to operate within it. At the individual level, the design of jobs either enhances or hinders workers' learning and skill development through the opportunities made available for variety, challenge, and discretion in the immediate work environment. At the organizational level, superior-subordinate roles are codified by the mechanisms of coordination and decision-making required to integrate activities, thereby allocating opportunities for authority, responsibility, and accountability among organization members.

The intent of joint optimization is to realize the full potential of the organization's resources in accomplishing its mission. This is accomplished in sociotechnical organization design by control of key throughput variance. Variance refers to any unprogrammed deviation from standards or procedures. A key variance is one which critically affects the desired outcome. This might be a deviation in the quality of raw material, the failure of an individual to take action at a critical time, the failure of a machine or other variations in input or throughput affecting goal accomplishment (Cherns, 1976; Pasmore et al., 1982).

Sociotechnical design focuses on appropriate boundary placement to control key variances. As Miller (1959) has discussed, boundaries can be drawn individually or in combination across such dimensions as time, territory, or technology. Sociotechnical theory prescribes that organization boundaries be drawn so that the work-related activities and roles of the members within the unit can be carried out in a manner which enables that unit to be self-managing in regard to controlling key variances. When boundaries are drawn inappropriately, other organizational subsystems can interfere with the unit's capacity to regulate itself. An example of this will be presented in the case concerned with the repair of close coupled pumps.

Principles of Sociotechnical System Design

Cherns (1976) maintains that there are choices available in the design of organizations, including those of the Navy. Historically, organizational design has been performed as an engineering function, with those responsible focusing solely on technical aspects such as space, tools, equipment and machinery, and allocating tasks to individuals or groups as though the people were appendages of the equipment. Layers of supervision are then created to integrate and coordinate the fractionated activities that result as a byproduct of this design process.

Unfortunately, little if any attention is paid to the social system. No attention is paid to whether or not the work provides adequate variety, challenge, and learning to engender motivation, concern for quality, and commitment to the organization's goals. At the organizational level, no review is made of whether or not the roles provided for members foster responsibility, timely decision-making, and the desire to be judged by one's performance. To realize choice in organizational design, designers must consider both technical and social factors. Cherns (1976) distilled the sociotechnical intervention literature and experience into nine principles,[1] providing insight into how this may be accomplished:

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[1] Davis (1982) expanded this list to 21 principles.

1. Compatibility
2. Minimal critical specification
3. Sociotechnical criterion
4. Multifunctional principle
5. Boundary location
6. Information flow
7. Support congruence
8. Design and human values
9. Incompletion

By implementing these nine principles, an organization will be capable of performing the four functions identified by Parsons (1951) as required of any social system. These are:

> Attainment of the goals of the organization; adaptation to the environment; integration of the activities of the people in the organization, including the resolution of conflict whether task-based, organization-based, or interpersonally-based; and providing for the continued occupation of the essential roles through recruitment and socialization. (Cherns, p. 784)

The accomplishment of these functions depends on the interdependent functioning of the technical and social systems.

Compatibility

In its simplest form compatibility requires that the means be consistent with the ends. Since most organization design entails redesign as opposed to new design, the discussion will focus on this domain. The purpose of redesign is to improve organizational effectiveness, creating an organization which fully utilizes its personnel, has greater flexibility in its functioning, and has greater capacity to adapt in a timely manner to environmental changes. Flexibility to adapt to change requires commitment on the part of members to organizational goals, commitment which cannot be attained through either fiat or command, but rather through an organizational design that engenders a high level of motivation to participate. From a design perspective, the goal should be an organization which functions in a more participatory manner. Research and theory in organization change has long favored involvement of organization members in the redesign process as the surest method for attaining participation and commitment. In addition, their involvement enables workers and managers to incorporate their experience and insights into the design.

Minimal Critical Specification

This principle asserts that only a minimal amount of behavior should be prescribed for organization members as a consequence of the organization design. The members, whether individual or group, need to know the goals they are to accomplish and the standards expected of them in terms of quantity, quality, cost, time, waste, or other relevant factors. Members also need to have access to necessary information, raw materials, appropriate skill training, and equipment in order to carry out their functions. There is no need, however, to carry the design restrictions further, that is, specifying how, when, or where the work is to be accomplished. Minimal critical specification is necessary to develop roles for members which afford them appropriate levels of self-esteem, responsibility, and decision-making while enhancing the organization's flexibility to adapt to environmental change.

The Sociotechnical Criterion

Some variance will always occur in the transformation process by which inputs are converted into outputs. According to this principle, when this event occurs it should be controlled at a point as close as possible to its origin, preferably at the level where the work is performed. Variance is defined as any unprogrammed deviation from standards or procedures. A key variance is one which critically affects the desired outcome, such as the quality of the raw material, the failure of someone to take action at a critical time, or the failure of a machine.

Typically, as organizations grow, the roles of supervisors and managers evolve to include control of variance in the work being performed. As organizations grow further, quality control departments evolve to perform the variance control function. Their intent in controlling variance, however, is not focused on reducing its occurrence, but rather assuring that poor quality products do not reach clients. Even if appropriate feedback mechanisms were in place, the capacity to identify the source of variance and to inform the individual or group in a timely manner is usually diminished due to time lags.

The sociotechnical criterion identified by Cherns requires that variance control be accomplished as a normal part of the transformation process. By training the individuals performing the work in the skills required to control variance and providing them with information to evaluate the correctness of their own actions, two important features for effective organizational functioning are created. First, it builds the feedback loop into the work itself. Individuals who receive immediate feedback can learn to correct the sources of variance in their work. Second, it upgrades the skills of members as they learn to monitor and take responsibility for their work.

Multifunctional Principle

Traditional organization design is built on fractionation of work, where each organization member is required to perform his/her task in the simplest possible form so that others can be easily and quickly substituted should replacement be necessary. The multifunctional principle asserts that there are benefits for both the individual and the organization if work is assigned in a manner which fosters development of multiskilled members.

From the individual's point of view, being multiskilled provides greater variety, challenge, and learning on the job. From the organization's point of view, a multiskilled person can enhance organizational functioning by rendering it less susceptible to the consequences of absenteeism and turnover while providing greater internal flexibility in meeting changing environmental demands.

When individuals work in groups responsible for the accomplishment of a whole product or goal, they can easily become multiskilled by exposure to the various skills of the other members. Group participation can thus enhance self-esteem by building pride in skills that have become broadened and which contribute to the overall organizational mission.

Boundary Location

Organizational boundaries are an artifact of organization design. Designers may create boundaries at the department, division, or shop level or even within a group of workers in the same shop. As mentioned earlier, these boundaries are drawn either

individually or in combination across such dimensions as time, territory, or technology. Once drawn they signal lines of authority, responsibility, and goal accomplishment. The principle of boundary location in a sociotechnical design asserts that, whenever possible, boundaries should be drawn so that the required personnel skills, authority, information, and other factors necessary for accomplishing the unit's goals are possessed by and under the control of the personnel assigned to that unit. Boundaries also affect member roles (e.g., the supervisor who performs many boundary maintenance functions, such as coordinating work with other units and acquiring resources).

Information Flow

All organizations, by design, have systems to direct information flow. In traditional organizations information normally does not flow downward beyond the level of the first line supervisor because supervisors and their managers are usually the agents who use the information to monitor organization functioning and who must take corrective action when necessary. In a sociotechnical system design information flows to the level where the work is being accomplished. Accurate and timely feedback is a necessary requirement for work unit members to monitor their own performance in order to control key variance and improve goal accomplishment.

Support Congruence

This principle states that organizational support systems should reinforce the behaviors which the organization structure is designed to elicit and the underlying management philosophy. If, for example, the design is based on group performance, the systems of reward should be congruent with the design. If it is not possible to obtain this in terms of direct remuneration, management should seek to produce a similar effect through other means, such as feedback mechanisms designed to recognize group accomplishments. In the same vein, support systems such as member selection, training, conflict resolution, and leave allocation should be congruent with the overall organization design. In the Navy setting, constraints and limitations may exist at lower levels which would inhibit the full implementation of this design principle. However, with creative use of design alternatives it would be possible to realize some congruence to support the functioning of the organization design.

Design and Human Values

This principle states that an objective of organization design should be to provide good jobs, that is, those that meet a person's work-related social and psychological needs. Thorsrud (1972) described good jobs as characterized by:

1. Content reasonably demanding in terms other than sheer endurance and yet providing some variety (not necessarily novelty).

2. Opportunity to learn on the job and to go on learning (again, it is a question of neither too much nor too little).

3. Opportunity for some decision-making that the individual can call his or her own.

4. Opportunity for some degree of social support and recognition.

5. Opportunity to relate what one does and produces to the needs of society.

6. Occasion to feel that the job leads to some sort of desirable future (not necessarily promotion).

Incompletion

This principle states that design is an on-going process. It recognizes that the environment in which the organization operates is not static but changes over time. The organization's design must be flexible enough to adapt to environmental changes. Thus, redesign becomes an on-going part of organization functioning.

The Process of Sociotechnical System Design

To proceed with organization design one needs a methodology which can be used to analyze system functioning, identify problem areas and causal factors, and generate and evaluate alternative systems of organization to accomplish desired goals. The socio-technical design process presents one such methodology based on the belief that joint optimization of social and technical systems is essential for successful organizational functioning. A series of steps are presented that help to understand system functioning, that identify areas that work against joint optimization, and that generate alternatives that can improve the system.

The steps and associated data collection instruments which comprise the sociotechnical design process are presented in their entirety in Davis (1967).[2] The following is a synopsis of them.[3]

Environmental Scanning

The first of nine steps in the sociotechnical design process is labeled environmental scanning. The purpose of this step is to identify the main characteristics of the production system by which the inputs are transformed into outputs and to pinpoint the broader organizational environment in which the system functions. The production system can involve either a manufactured product or its repair, information processing, or service to clients. The focus here is to determine problems of integration or coordination and where subsequent analysis should be directed. Environmental scanning can be carried out by the consultant in collaboration with either staff or key resource people.

The next two steps in the design process focus on technical system functioning. These two steps are best accomplished by the consultant working in collaboration with both supervisory and nonsupervisory personnel involved in the work system under study.

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[2] Davis and Wacker (1982) present a more elaborate framework for job design from a sociotechnical system perspective.

[3] In certain organizational settings, due perhaps to culture or management philosophy, it may not be possible to follow the sociotechnical design process in its entirety. However, if the consultant is familiar with the types of knowledge and information bases which the sociotechnical analysis provides, it is still possible to use the general framework and obtain positive results.

Identification of Unit Operations

The first step in analysis of the technical system is identification of unit operations. According to Davis (1967),

> Unit operations are . . . the main segments or phases in the series of operations which have to be carried out to convert the materials at the input end of the system into products at the output end. Each unit operation is relatively self-contained and effects an identifiable transformation in the raw material. (p. 1)

By transformation, Davis means a change of state, location, or storage of the material. For instance, the unit operations in manufacturing a leather belt can be described as: Draw a pattern on leather, cut out the pattern, smooth the edges, punch holes, pour metal into belt buckle cast, let cast set, remove buckle from cast, smooth edges of buckle, tool any designs, stain it, and rivet belt onto the buckle.

Identification of Key Process Variances

The second part of the design process related to technical system functioning is identification of key process variances and their interrelationships. Variance is defined as a deviation from some standard or specification. Key variances are those which significantly affect any one of the following: "quantity of production, quality of production, operating costs (e.g., use of utilities, raw material, overtime), or social costs (e.g., the stress, effort, or hazard imposed on personnel)" (Davis, 1967, p. 3). The purpose here is to identify unit operations where a deviation from some standard or specification significantly affects desired end results. Once the key variances have been identified it is possible to consider alternative control systems to insure that key variances are held within limits. For instance, in the belt-making example, the size and placement of the hole for the rivet holding the buckle could be considered to be key; if it is too large or off center the buckle will not stay fastened or appear cocked.

The control of variances is largely accomplished by people performing roles in a social system. The next two steps in the design process focus on analysis of social system functioning. These steps are probably best accomplished through the construction and administration of a questionnaire designed in collaboration with managers and supervisors associated with the work system under investigation. This may also be accomplished through interviews with key organization members.

Macro Social System Analysis

First, a macro social system analysis is conducted to investigate the extent to which the present functioning of the social system complements the workers' capacity to control key variances at their point of origin. This analysis is intended to identify what new organizational relationships or informational loops might be required in order to accomplish key variance control.

Micro Social System Analysis

Next, a micro social system analysis is conducted to evaluate the workers' perceptions of their roles. Areas of concern in this analysis include whether or not workers perceive their roles as being responsible ones that foster commitment and fulfill psychological needs (e.g., opportunities for variety, challenge, and decision-making).

The next three steps focus on relationships between the work system and support functions and policies. These steps should be carried out by the consultant in collaboration with an action group comprised of top management along with representatives from the managerial and supervisory levels of the system under investigation.

Analysis of the Maintenance System

The analysis of the maintenance system focuses on the relationship between the equipment maintenance system and the work system under investigation. It does not investigate in detail the internal operation of the maintenance function in the organization, but rather identifies the extent to which the maintenance system affects the capability of the work system to achieve its objectives. This is done by identifying maintenance-related variances and associated control mechanisms and evaluating the appropriateness of boundaries that cross functional lines, e.g., repair versus maintenance. The boundaries are examined to determine whether or not improvements in the work system might be achieved through incorporating some maintenance functions into work system roles.

Analysis of Supply, Staff, and User Systems

In similar fashion, the analysis of supply, staff, and user systems focuses on identifying the extent to which these systems affect the capability of the work system under study to achieve its objectives. For instance, in the case where workload planning and scheduling are specialized functions external to the work system under investigation, it is important to identify where and how present functioning of these support systems might have negative consequences on the work system. Once again, a key focus of these analyses is on the appropriateness of boundaries that cross functional lines.

Future Scanning

Naturally, aspects of the environment or the technology relevant to the work system under study are likely to change in time. To the extent that it is possible to obtain information about intended changes these should be incorporated into the new work system design. Two specific areas to be scanned are (1) development plans for the technical or social systems, and (2) planned alterations in general organization or policies, such as Navy supervisory training for senior enlisted personnel that would affect the social system or automated data processing (ADP) equipment acquisition policy that would affect the technical system.

Developing Proposals for Change

The last step in the design process is developing a proposal for change which systematically addresses the problems and issues raised in previous steps of the analysis. This consists of gathering together all of the hypotheses and proposals that have been developed during the process of analysis, considering their viability in terms of the production and social objectives of the organizational system, and presenting them with sufficient structure and information to form the basis for an organization change program. This proposal should be drafted by the consultant in collaboration with the organization members who participated in the analysis.

WORKING WITH THE CLIENT

The Setting

Military and Civilian Mix

Clients vary in many ways, one of the most important being the mix of military and civilian personnel. Because each group has different factors influencing its behavior and creating differing cultural norms and expectations, these differences in military/civilian mix have a number of implications for organization redesign efforts.

Wherever military personnel are present the personnel turnover rate is relatively high because of their two- to three-year tours. Military personnel expect to rotate through a succession of jobs, as many as several in a single tour of duty, each one calling for development of new skills or new applications of their present knowledge and skills. These frequent job changes create an almost continuous requirement for learning new roles and technical skills. Thus, military personnel are likely to acquire a generalized knowledge and expertise and a broad professional identification over their careers through exposure to a wide range of tasks, applications, and military settings (Cherns, 1979a, 1979b).

Military culture is one where decisiveness is a normative ideal for leaders, based on its usefulness in battle. This may translate into the aura of perceived competence in a leader based on "taking command," while a more participative or reflective management style may be perceived by some as weak or indecisive.

In contrast, civilians tend to be less mobile and pursue a hierarchical career path through a small number of organizations. They are more likely to specialize over time, building a professional identification with a discipline. Although civilians undoubtedly experience a wide range of management styles, especially where high levels of technical training are involved, there is high receptivity to participative management and expertise-based decision-making.

Motivation is also likely to differ qualitatively between military and civilian workers. Rotation from sea to shore is likely to result in military personnel wishing to be compensated for being overworked and under continuous high stress while at sea by less intense activity and more release time during shore assignment. On the other hand, civilian personnel are likely to adapt to the relatively stable pace of the organization to which they belong, rising to the occasional crisis as required but generally resigning themselves to time lags produced by "regulations" and "procedures" even though schedules are not met. Motivation among civilians is likely to reflect factors such as promotion potential, which is of less interest to military personnel whose promotions are largely determined initially by time in grade. However, military personnel, especially senior enlisted and officers, are highly aware of their being evaluated by superiors, as recorded in fitness reports.

Change Consequences

Differences in organization culture and personal orientations of military and civilian personnel are likely to be reflected in differences in willingness to change, the bases for acceptance of change, the acceptable rate of change, and the long-term durability of change. For military personnel, the most important consideration regarding change may be who advocates it rather than how it is accomplished or the extent of impact. If the

Commanding Officer (CO) is behind it, very little issue is likely to be raised by subordinates. Their primary goal is to exercise competent short-term stewardship to get the job done as expediently as possible, thereby satisfying their CO. Due to their short period of tenure in any particular role, they have minimal concern with long-term personal consequences of a change. Thus, their only long-term concern is a general feeling of responsibility to their replacement and the command.

On the other hand, civilian personnel are more likely to endure the consequences of change over an extended time period. Their perspective tends to be long-term and their concern over change is tied to career. Thus, even though the CO favors a change, the civilian's perspective may be one that extends far beyond the tour of that particular CO. There may be initial passive acceptance of change followed by efforts to cancel the changes when leadership changes. When a change reduces a civilian's level of responsibility or jurisdiction and will possibly change the grade level and salary, there is considerable resistance to change. To the extent that such resistance is at variance with attaining organizational goals, it can impede constructive change.

The bases for acceptance of change are also likely to vary between military and civilian personnel. Military personnel are more apt to focus their concerns on whether or not the changes will be beneficial to the organization's mission. They are also likely to have less personal investment in a particular way of doing things. Civilians, on the other hand, are more likely to include in their consideration of a proposed organizational change whether or not it would affect their own careers. They might also raise objections to the inclinations of military personnel to continually "tweak the system" in search of improved performance.

The rate of change can also vary across organizational settings. Consultants should expect a higher level of initial resistance to change, especially at lower and middle supervisory and management levels, in organizations having a higher proportion of civilian personnel. As stated earlier, civilians are usually pursuing long-range career goals, are moving toward specialization, and are concerned with "territorial" issues. For these reasons the time it takes to implement change may often be longer than otherwise.

When the system has a high proportion of military personnel at all levels there generally will be less resistance to change. Change is viewed as a normal event in military life, and support for command decisions concerning changes is expected. There is a sense of stewardship rather than of territorial ownership toward one's organizational role. There is also less concern about specialization in one's career. Therefore, in settings with a high proportion of military personnel, consultants can expect more rapid implementation of change.

For many of the reasons cited earlier, changes accomplished in organizations with a high proportion of military personnel are less likely to become institutionalized or endure over an extended period of time. The high turnover rate of military personnel makes it difficult to maintain corporate knowledge across multiple generations of personnel. While learning their new roles in the ongoing system, incumbents are under pressure to make their mark in mission performance. Their curious, questioning, improvement-oriented perspective, combined with "command prerogative" for those in leadership positions, predisposes them to look for ways to make positive changes. Though this may be advantageous when initiating change, it can compromise any work system design that is in place.

Civilians are more likely to have a stabilizing influence on system change. They are more likely to recall relevant past experiences concerning system design issues and appreciate historical reasons for previous changes in the work design due to their longer time in the organization.

Regardless of the personnel mix there are a number of important preconditions which affect whether or not a sociotechnical system design approach will successfully solve the problem(s) of the client.

Prerequisite Conditions for Sociotechnical Design

The initial invitation from the client organization is based on some felt need for improvement. Often, however, management has already defined what it believes to be the problem and has determined what kind of solution should be sought. Such preconceived notions preclude proper use of a sociotechnical system analysis, which requires collaborative problem definition derived from a systematic, data-based analysis of the client system.

In initial contacts with the CO it is important to help him understand that sociotechnical system design requires time and resources to define the problem and that any changes will require an extended period of time for implementation. In other words, sociotechnical design requires a long-term, problem-solving approach rather than one that is short-term and crisis-oriented.

The attitude toward planned change and the receptivity to an external change agent must extend beyond the CO. There must be a shared appreciation throughout the command of the importance of improved organizational effectiveness. This may be more easily achieved in organizations with a high proportion of military personnel because of their propensity to focus on mission accomplishment and respond positively to command concerns. This can be fostered by concentrating on an area of performance that is central to the client system's mission. It is relatively easy to build a consensus of support if personnel realize that the effort and resources expended in the analysis will be recouped through increased output.

Finally, a critical factor in the sociotechnical design process is availability of data on past performance, essential for establishing a baseline as a means of evaluating future changes. It is sometimes possible to obtain the necessary baseline data from historical records of the organization; however, it is quite likely that supplementary data along with some mechanism for generating it will be required.

Intervention Strategy--The Collaborative Approach

The sociotechnical principle of complementarity requires that the consultant work collaboratively with key personnel from the organization under study. The following steps characterize the collaborative approach to organization redesign:

1. Collaborative clarification of objectives.
2. Joint identification of issues and problems.
3. Collaborative generation of alternative solutions.
4. Consensus building across management levels.
5. Establishment of command sanction for proposed changes.
6. Facilitation of change.
7. Joint monitoring and evaluation of the new design.

These are discussed briefly below.

Collaborative Clarification of Objectives

Most often the consultant will be invited by the client to address a particular problem. At this stage the consultant should bring to the client's attention any reservations about the presenting problem, that is, that it might be a symptom and not the cause of poor performance. To address this possibility an analysis of the organization should follow.

Joint Identification of Issues and Problems

Problem identification should be pursued using a collaborative process. Collaboration can be accomplished in a number of ways. Ideally, a task force comprised of the consultant and knowledgeable members of the client organization should be formed to work through the steps involved in sociotechnical system analysis. Although many scenarios are possible for formation of a task force, two will be described. One possibility is for the consultant to individually involve key persons in the design process as it unfolds and touches their area of responsibility, eventually bringing participants together when an occasion arises for a major decision or action. A contrasting approach would be to seek command appointment of selected personnel representing relevant functional areas and various levels of responsibility. If this is not possible, the consultant can perform the analysis independently, utilizing members of the client organization to provide information and to act as a sounding board regarding the validity of issues or problems which are uncovered.

The sociotechnical analysis will most likely identify design-based problems in the functioning of the organization. Some of these may reside within the subsystem under investigation (e.g., its capability to control key variances in the throughput process). Other problems may concern existing coordination mechanisms which integrate staff support functions with the subsystem under investigation. A third possibility is that organizational policy might be hindering performance. In any case, the consultant should work with organization members who are knowledgeable about the issues and problems identified as well as other personnel who would be affected by changes in these areas.

Collaborative Generation of Alternative Solutions

The collaborative process should continue during generation of alternative solutions. Organization members who have experience in the particular domain(s) under consideration are primary sources of ideas, concepts, or other facets of solutions for the problems identified. As these ideas and concepts are gathered, they should be integrated into a proposal for change.

Consensus Building Across Management Levels

It is likely that proposed solutions will involve changes in organization functioning beyond the specific unit under study, such as changes in support functions and policy. Therefore, it is important to share this information with all relevant managers across various levels of the organization so that consensus building regarding solutions can continue. This is necessary to engender a high level of commitment throughout the organization for the proposed change program. General consensus should be sought at a formal meeting involving all parties, preferably chaired by the executive officer, where the goal is resolution of all issues before meeting with the CO.

Establishment of Command Sanction for Proposed Changes

Following the establishment of a consensus, the results of the sociotechnical analysis and associated recommendations should be summarized in a proposal for presentation at a formal meeting with the CO. The proposal should be submitted to the CO in advance of the meeting so that the person has time to formulate any questions regarding the problems and recommendations. The intended outcome of the meeting is to obtain sanction regarding the changes to be implemented and approval of the proposed action plan and milestones. After this meeting the focus shifts to facilitating implementation of the changes.

Facilitation of Change

The consultant has two responsibilities to carry out at this stage, to function as a resource person and to help the client take over the new system. As a resource person the consultant must coordinate the activities of the detailed redesign process, drawing in knowledgeable persons as required and aiding managers in resolving problems encountered during the change process. The consultant must also "disengage" from the client system, doing this in such a manner that the client develops the capability to continue monitoring and controlling the redesign process and, as required, adapting to continued environmental changes. Thus, an underlying goal of the consultant during the process is to cultivate the client system's ownership of the design process and its results, building knowledge within the organization members regarding sociotechnical design so that the organization can perpetuate the newly learned process over time.

Joint Monitoring and Evaluation of the New Design

The concluding step involves monitoring and evaluating the new organization design during its subsequent functioning. Monitoring should include maintaining contact with the client system, keeping informed of any problems which arise, and collaborating in assessing whether additional redesign is required. An evaluation should be conducted by the consultants to assess the effectiveness of the redesign on system outputs over a representative period, such as a year, following the change.

THE CASE--PUMP REPAIR AT SIMA, SAN DIEGO

BACKGROUND

Organizational Setting, Mission, and Inputs

Navy Intermediate Maintenance Activities comprise a network of tenders and shore installations which provide maintenance and repair support for the Fleet. They are manned and managed by military personnel. The SIMA, San Diego, is the largest, with 1800 personnel. It has 57 repair shops organized into 5 branches within the Production Department (see Appendix A).

One critical element in the mission of SIMA, San Diego, is overhaul of pumps from Pacific Fleet vessels assigned to that installation by the Maintenance Control Center of Commander of Naval Surface Forces Pacific (COMNAVSURFPAC). The responsibility for this work resides in the Pump Repair Shop, called "38C," which employs about 70 people.

Once a pump repair job has been accepted by SIMA it must be planned and scheduled, parts procured, and the pump processed via 38C, acting as lead work center, and multiple

assist work centers (AWCs). The inputs to 38C, both pumps and personnel, are highly variable. Pumps come in many types and sizes, are designed for various applications, originate from a variety of shipboard settings, and arrive in a wide range of conditions depending on age, prior maintenance, and use. The usual overhaul restores the pump to original design specifications. This requires the coordinated effort of many production shops and support systems.

There is also a high degree of variability among personnel in 38C. Turnover is programmed at a high level, approaching 60 percent per year. This high turnover rate poses severe problems in regard to maintaining smooth system operation, transmitting operational knowledge, and retaining the skills needed for pump repair. SIMA faces a continuous training requirement because incoming personnel are seldom thoroughly trained in the skills required for pump repair. Although training is SIMA's second priority, production demands have often displaced that effort.

Environment

The environment that 38C must interact with is and will continue to be "turbulent," that is, uncertain, unstable, rapidly changing, and not amenable to control by the shop. This condition makes it difficult, if not impossible, for 38C to perform its work in any kind of programmed way. The demand for 38C's services originates with the Fleet in accordance with its operating schedule and maintenance requirements. Procedurally, ship availability for maintenance is scheduled in advance; however, due to numerous forms of emergent work and changes in ship schedules, none of which are under the control of 38C or SIMA, the planned work activities of 38C and its AWCs are often disrupted on short notice.

Availability of parts and materials is also partially outside of the control of 38C and SIMA, often resulting in delays. Negative consequences include rescheduling of work, increased overtime, and disruption of work on other scheduled jobs.

History of Initial Changes

In 1982, SIMA command became concerned over productivity problems in 38C. From the command's perspective, the shop was performing at consistently low levels. Production was low, quality was uneven, and overtime was excessive.

In 1983, a new officer assumed management of the Machinery Branch, which included 38C. Determined to solve the productivity problem, he reviewed the current operation and organization of 38C and investigated alternative approaches to work system design in batch production settings.

The new branch officer's review revealed that the shop was organized into two work groups of 15-20 persons. One group was responsible for removal of the pump from the ship (when required), disassembly, ordering of parts, and farming out of components to AWCs. The other group reassembled and tested the pump and reinstalled it aboard ship. He concluded that 38C's prior poor performance record was in part due to its organization. Workers lacked identification with the repair process and the product. Dividing the repair process in two and assigning work within the two groups on the basis of personnel availability created problems of accountability. This system also created difficulty in parts procurement and tracking of work through the AWCs.

Based on his review of the 38C operation and organization in conjunction with review of articles in the popular press and talks with managers in SIMA and the private sector, he changed the 38C organization to one based on work teams.

The change resulted in five work teams made up of seven members each, one of whom became team leader. These teams were self-managing and their tasks were shared among members. Each team was given comprehensive responsibility for the repair of assigned pumps, including in-process inspection and participation in final testing. As part of the overhaul process each team ordered parts and materials. They also initiated and tracked work for their pumps through the necessary AWCs. Planning and scheduling information was provided to the teams by the centralized Planning Department, enabling them to coordinate all efforts toward completion of the repair in a timely manner. Monthly group performance feedback in terms of pumps completed was provided and posted publicly in the work space along with team membership. Team members were able to compare performance across teams as well as their own performance over time. Finally, modifications in tools, equipment, and space were made to support team functioning.

Factors Affecting Initial Changes

Based on literature pertaining to the use of autonomous work team designs in batch production settings, one would expect improved productivity as a result of the shop-level redesign (Friedlander & Brown, 1984; Pasmore & King, 1978; Srivastva et al., 1975). However, this case involved factors that made it unique and could have impeded the attainment of productivity increases. The change agent was a line officer who lacked experience in planned organizational change and did not receive assistance from anyone with special knowledge of organizational design. The intervention process did not include participation by personnel affected directly by the change. The line officer created what he believed would be a workable organization, consulted his immediate subordinates, and then initiated the change by directive. Thus, a sociotechnical design was implemented without the aid of a sociotechnical analysis or participation by members.

Several other factors could have impeded the new system. Navy culture tends to offset extended family separations and high workloads experienced at sea by tacitly accepting lower productivity during shore assignments. Also, all military organizations experience high planned rates of turnover at all levels. In the present case, turnover is 60 percent annually. Lastly, incoming personnel have had little or no prior experience in the repair process and require training to acquire requisite skills.

Evaluation and Discussion of Initial Changes

Evaluation

After trial of the new work system design, it was judged by management to be a success. A longitudinal analysis was performed by NAVPERSRANDCEN consultants as part of the second phase of the project to quantitatively determine the impact of the work system change on productivity. A 12-month period prior to the installation of autonomous work teams was compared with a 12-month post-change period, allowing for a four month transition period.[4] Evaluation was made on three measures:

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[4] Twelve months was the maximum period possible prior to implementation of changes recommended in the analysis phase of this project.

1. Average number of pumps completed per month, adjusted for available production man-hours.

2. Average monthly production efficiency (in percent), calculated by dividing documented man-hours expended on completed jobs during the month by available production man-hours for the period.

3. Average monthly job efficiency, calculated by dividing estimated man-hours (from SIMA Standards Manual) for pumps completed plus documented man-hours on cancelled jobs by available production man-hours for the period.

Table 1 presents the results of the longitudinal analysis that compares productivity before and after the change to work teams. It shows that the change produced substantial improvements.

Discussion of Results

In essence, the change in organization design implemented by the branch officer incorporated five of the six most prevalent features of sociotechnical design as identified by Pasmore et al. (1982) in their review of sociotechnical interventions in North America. These included: (1) multiskilled autonomous work teams, (2) technical emphasis in training, (3) group level reward system, (4) work team self-inspection of output, and (5) technological changes to support a team-based organization.

The change to autonomous work teams also incorporated other features of sociotechnical design. These included: (1) minimal critical specification of team functioning, (2) monthly feedback of group performance, (3) team-shared interface with customers, (4) team responsibility for acquisition of repair parts and materials, and (5) managerial information provided to team members.

Table 1

Evaluation of Work Team Design in the Pump Shop[a]

	Pre-team concept	Team concept	Change
Average number of pumps completed per month adjusted for manning level	40.0	56.0	+40%
Mean production efficiency	72.6%	87.5%	+21%
Mean job efficiency	64.3%	94.6%	+47%

[a]Comparison is between the period February 1982 through January 1983 (pre-team concept) and the period June 1983 through June 1984 (team concept). This reflects a four-month transition period (1 February-31 May 1984) and one month during the operation of the team concept for which data are missing.

Close examination of the change to autonomous work teams reveals that five important features of the setting apparently contributed to its success: (1) the tradition of Navy command, (2) the nature of the environment of SIMA and 38C, (3) the technology employed within 38C, (4) the nature of the task and performance feedback, and (5) the requirement to provide training to incoming personnel. These are discussed below.

1. The change to autonomous work teams was carried out by directive, a violation of the compatibility principle of sociotechnical design (Cherns, 1976). In this setting, however, "command prerogative" (a central feature of Navy culture) legitimized the change.

2. Environmental factors also contributed to success of the new design. Ships repaired by SIMA often change their schedules as well as their work packages which define what needs repair. These unpredictable changes force SIMA and 38C to continually change priorities. Fortunately, "organic structures" (Lawrence & Lorsch, 1967), here characterized by autonomous work teams, possessed the required flexibility for adaptation (Davis, 1977).

3. The work team design employed in 38C was well suited to small batch production (Woodward, 1965). Pumps come in such a variety of types, sizes, and condition that on a yearly basis many represent unique inputs. Thus, a standardized procedure of repair cannot be specified. Given the high number of pumps with unique features that require special repair, work teams seemed to be a form of organization suitable to the task (Perrow, 1967).

4. The nature of the task and performance feedback in 38C contributed to overcoming the problem of motivation. Assigning teams the complete responsibility for a product and providing regular feedback of performance engendered identification with the product and enhanced motivation (Davis, 1966).

5. The work team design was successful in addressing the limitations of a high planned turnover rate and low skill level of incoming members. Working in a team provided an effective mechanism for rapid skill acquisition by incorporating on-the-job training of repair skills among team members as part of normal group functioning (Davis, 1966).

In summary, the setting was amenable to the non-participative process of change due to its Navy context. The exceptionally good fit between the work team design and the shop's environmental and technological characteristics played an important role in overcoming shortcomings in organizational culture, turnover rates, and personnel skill level. The flexibility of the work team design allowed 38C to cope with its turbulent environment. Autonomous team functioning enhanced motivation and provided natural opportunities for continuous skill acquisition by its members.

The change to autonomous work teams in 38C was implemented without attempting to make complementary changes in the structure and functioning of the rest of the organization. This omission has both theoretical and practical implications. Open systems theory holds that system functioning encompasses both the interrelationship of its parts and its interdependence with the larger system (Emery & Trist, 1960; Katz & Kahn, 1966). In this case initial changes focused on work relationships within 38C, but ignored 38C's interdependence with SIMA. Davis (1979) contends that organization design must encompass changes in the larger system to complement changes in lower level structure and functioning.

This lack of comprehensiveness in organization design is not unique. In their review of 134 sociotechnical studies in North America during the 1970s, Pasmore et al. (1982) found that relatively few attempted to go beyond autonomous work teams to consider changes in related aspects of organization structure and functioning. They concluded that this had serious practical implications because ". . . the best efforts seemed to be those which are more systemic in focus" (p. 1198).

The lack of complementary changes in the larger system also endangers the longevity of changes introduced, given pressures for uniformity which have a tendency over time to undo much of what a sociotechnical design can accomplish (Pasmore, 1982; Walton, 1975). Longevity is of particular relevance in the present case. Even though the initial change was an apparent success, SIMA management was concerned that the benefits derived from the new work system would regress due to two factors. First, the high planned rate of turnover at all levels would tend to reduce corporate knowledge of the rationale and responsibilities required to maintain the new work system design. Second, autonomous work teams are anomalous to Navy culture in that they decentralize decision-making and responsibility traditionally retained by senior enlisted and officer personnel.

ORGANIZATION REDESIGN PROBLEMS AND SOLUTIONS: CLASS EXERCISES

SIMA management's concern over the longevity of the new organization in 38C led to NAVPERSRANDCEN being invited by the CO of SIMA to assist in analyzing and evaluating the new form of organization, institutionalizing it, and transferring it to other repair units.

Several methods were used to gain an understanding of the conditions which affect the operation of 38C. These included structured and unstructured interviews, observation, and the analysis of historical records.

The first step was to examine the environment of the Pump Repair Shop. This focused on the normal paperwork flow from the COMNAVSURFPAC Maintenance Control Center through SIMA, including work acceptance, planning, scheduling, ordering of parts and materials, and procurement of necessary technical documentation, culminating in a work package for 38C and its primary AWCs.

The second step was to examine the Pump Repair Shop itself, including the process of pump repair, various management and supervisory inputs, and relevant aspects of the information system. This was followed by investigation of 38C's interrelationships with its primary AWCs and the AWCs' internal processes. Here, the analysis focused on the coordination between work systems as well as the management, supervision, and work system design in each of 38C's primary AWCs.

As information began to accumulate it became apparent to the researchers that conditions that had a major influence on 38C extended beyond its boundaries to include primary AWCs and various SIMA support functions. To be able to act on this new knowledge, the researchers formed a task force comprised of key personnel from all major areas related to pump repair. Initially, this was done informally with the researchers approaching key personnel for information, critical evaluation, and feedback. As these personnel began to recognize their contribution to improving the design of the pump repair system, their involvement became more formalized through meetings planned to develop consensus regarding major issues.

Findings: Work Team Design in 38C

Though the work team design in 38C was judged to be an appropriate form of organization, problems were identified in five areas: (1) measurement of team performance, (2) feedback of team performance, (3) orientation for management personnel, (4) team leader supervisory training, and (5) tools and equipment.

Measurement of Team Performance

Problem. Initially, team performance was measured by the number of pumps completed per week or month. This was used for determining the "best" team and became the basis for team recognition. Two associated problems occurred. First, all pumps were counted equally, which resulted in a built-in error (i.e., some pumps took longer to repair or required more knowledge or skill than others). Second, most of the work on a pump might be performed in a month different from the one in which the job was completed.

Exercise. Recommend a measurement system for team performance which overcomes both of the problems identified.

Researchers' Recommendation. Measure team performance monthly as a ratio of estimated hours required for pump completion (EH_c) plus actual hours worked on cancelled jobs (AH_c) divided by the team's available man-hours (AvH) to yield a team's job efficiency index (JEI_t):

$$JEI_t = \frac{EH_c + AH_c}{AvH}$$

Calculate a moving average over ten-week periods to minimize fluctuations caused by work scheduling.

Rationale. The job efficiency index provides a more valid performance measure by weighting number of pumps completed by estimated hours required for each. Estimated hours drawn from SIMA standards are preferred to documented hours reported by the shop because they are less subject to manipulation. By taking into account a team's available man-hours the index reflects performance efficiency on a scale which allows reliable comparisons among teams. Averaging over a 10-week period minimizes fluctuations due to work scheduling.

Action and Discussion. Team members, team leaders, and shop supervisors agreed that the present system of measuring team performance did not provide valid feedback. They also felt, however, that the JEI was overly complex and likely to be cumbersome to administer.

To address this problem, the leaders of the pump repair teams and the shop documenter were asked by the researchers to develop a weighting scheme reflecting the differences in pump type, size, and condition upon arrival for repair. They developed a pump point schedule by which the documenter is able to objectively assign from one to five points for type and size and one to five points for condition. This results in each pump having an assigned value of from two to ten points upon arrival at the shop. The

documenter adds up the point values of the completed pumps each month to arrive at a score for each team. These scores are fed back to the teams on a monthly basis along with the pump count.

Two major reactions emerged among team members during a trial of the pump point system. First, they felt the point system added valuable information to the count of pumps completed. Second, they registered greater interest in doing larger or more difficult pumps because the point system gave them "credit" for the greater effort and skill required.

Examination of the data shown in Table 2 for the trial of the pump point system reveals that monthly pump points discriminate clearly between teams producing at the same level in terms of pump count alone. The rank ordering of teams under the two systems often deviates within a given month, but not by more than one position. However, there may be extreme fluctuations in the rank ordering of teams from month to month because most of the work on a pump may be performed in the month prior to the one in which the job is completed (note the scores for teams 5 and 6 from September to October). To minimize this effect in the point total, the documenter computes a moving average over two months.

Feedback of Team Performance

Problem. Under the initial system of performance feedback, lower ranking teams could experience negative feedback even when they were performing at a high level.

Exercise. How could performance be measured so that a team performing well would not receive negative feedback?

Researchers' Recommendation. The Machinery Branch Office and members of the teams in 38C should establish a challenging, yet attainable standard of performance for the JEI based on analysis of past performance. All teams should receive monthly performance feedback based on a moving average of the JEI.

Rationale. Using the JEI as the basis for feedback can eliminate the potential problem of unwarranted negative feedback. Under ideal conditions, where all of a team's available man-hours are used productively, the JEI will equal 1.0. A realistic standard must be set for acceptable team performance based on the JEI. Teams performing at or above this standard are performing at an "acceptable" level. This system of performance feedback enables all teams to receive positive recognition for their efforts in a given time period, and yet does not preclude rank ordering of teams as a measure of relative excellence.

Action and Discussion. No action was taken on this item. It was the opinion of SIMA management that competition was part of Navy culture and that it created an inducement for high performance. That inducement could be lost by providing a minimum standard, possibly influencing team members to let performance drop to the minimum acceptable level.

Orientation for Management Personnel

Problem. There did not exist any systematic orientation for incoming branch- or shop-level management personnel. Orientation only occurred by chance when there was overlap in the assignments of incoming and outgoing personnel. Even when this did occur

Table 2

Pump Repair Team Performance Measured by Weighted and Unweighted Production Count

	Performance											
	September				October				September/October Average			
Team	No. pumps	Team rank	Pump points	Team rank	No. pumps	Team rank	Pump points	Team rank	No. pumps	Team rank	Pump points	Team rank
1	12	5	55	5	4	6	14	6	8.0	6	34.5	7
2	13	3	63	3	6	4	28	4	9.5	2	45.5	3
3	13	3	61	4	6	4	22	5	9.5	2	42.5	6
4	16	1	77	2	7	3	31	3	11.5	1	54.0	1
5	6	7	32	7	12	1	54	1	9.0	4	43.0	5
6	15	2	89	1	2	7	8	7	8.5	5	48.5	2
7	8	6	47	6	8	2	40	2	8.0	6	43.5	4

there was no uniformity in coverage of the important content areas. This created obvious problems due to the complexity of the pump repair process and involvement of SIMA staff and multiple AWCs. In addition, the operation of the team-based organization in 38C was likely to be unfamiliar.

Exercise. Design a management orientation program that addresses both content and delivery.

Researchers' Recommendation. Incoming shop management personnel should receive systematic exposure to the way the pump shop interacts with its primary AWCs and with SIMA support with regard to work acceptance, planning, scheduling, supply and material procurement, and the management information system as they affect shop performance. This orientation to the pump repair system should be developed using video tapes supplied to the Machinery Branch for indoctrination of new personnel soon after arrival.

Rationale. The high rate of personnel turnover requires that the shop be able to provide for continuous or frequent orientation of incoming individuals. These orientations should be presented in a uniform, systematic, and comprehensive manner to reduce the gap in knowledge about how the system works. Rapid indoctrination will also help to maintain high levels of production. In the researchers' opinion, video tapes provide the most efficient means for this activity.

Action and Discussion. A content outline for the orientation program was developed by the researchers and reviewed by the task force (Appendix B). The concept was approved and production of the video tapes awaits funding.

Supervisory Training for Team Leaders

Problem. A systematic training program for incoming shop-level supervisory personnel did not exist. Assignment to the role of team leader is based on rating. Training only occurred by chance when there was overlap in the assignments of incoming and outgoing personnel. Even under ideal conditions there was no uniformity in coverage of the important content areas. This created problems because teams are critically influenced by the effectiveness of their leaders. Incoming team leaders seldom had prior experience in either pump repair or team-based organization as they function in the pump repair process at SIMA, San Diego.

Fundamental to performing the role of team leader is the ability to coordinate and control team responsibilities. At a minimum this encompasses (a) scheduling and tracking assigned jobs, including work performed on various parts of the job through multiple AWCs, (b) accurate recordkeeping, (c) providing technical training and technical supervision of team members, (d) providing leadership in repair activities, (e) allocating personnel resources across jobs, and (f) coordinating with other units of SIMA for rigging, craning, and transportation.

Exercise. Design a supervisory training program that addresses both content and delivery.

Researchers' Recommendation. Incoming team leaders should receive systematic exposure to the entire pump repair process as it is performed at SIMA, San Diego, including the nature of the team-based organization and the interdependence of pump repair teams and their primary AWCs. Key roles in the pump repair process should be highlighted, focusing on their own responsibilities for supervision, training, production

control, and coordination. Early indoctrination of new personnel is of paramount importance. This indoctrination might be most effectively accomplished by use of a videotape that individuals or groups could use. It is advisable for team leaders to view the management orientation tapes also.

Rationale. Video technology enables efficient delivery of team leader training on an individual basis, essential because of the high turnover rate. In view of the key role of supervisory personnel in attainment of high productivity and quality of work, it is important that they quickly reach an acceptable level of knowledge regarding system operation and their role in maintaining it.

Action and Discussion. The concept was approved. For purposes of efficiency and education of other members with whom team leaders interact, it was decided to combine the team leader training with the orientation for shop personnel (Appendix B). This work awaits funding.

Tools and Equipment

Problem. The inventory control system for tools and equipment relied on individual tool checkout from a central tool crib. This process caused a number of problems. First, productive time was lost each day as workers waited in line during high demand periods. Second, gross inefficiencies occurred when performing work on board ship due to tools being omitted when they were checked out on an individual basis. Third, due to time pressures, inventory control records for individual tools were poorly kept and many tools were lost.

Furthermore, the ease and speed of performing work was often hindered due to lack of adequate equipment, particularly apparent in the basic disassembly and reassembly process where power tools could have provided valuable assistance.

Exercise. Recommend ways to improve equipment to ameliorate the problems identified.

Researchers' Recommendations. Custom cabinets with selected tools arranged in an orderly manner should be provided to each team for work in the shop. Portable tool kits designed for specific tasks should be provided for checkout when performing work on board ship. Requirements for cabinets and tool kits should be established by the members of 38C. Finally, pneumatic wrenches should be provided to each team for pump disassembly and reassembly.

Rationale. Custom tool cabinets have been effective in the Navy air community. All tools necessary for the job are at the immediate disposal of team members. Efficient inventory control of the tools by the shop is also ensured. Pneumatic wrenches speed up pump disassembly and reassembly.

Actions and Discussion. The first step in improving tools and equipment was to install a compressed air system throughout 38C. Next, custom tool cabinets were designed and are in the process of being supplied one to a team. Each cabinet will be equipped with a standard set of hand and pneumatic tools arranged in such a manner that inventory will take only a glance. These cabinets will be supplemented with portable tool kits designed for shipboard tasks.

The first two cabinets, with a full complement of tools, were procured for trial use and evaluation. Additional cabinets will be acquired as budget allows. Portable tool

boxes for shipboard tasks are also being evaluated. Such tool cabinets and portable tool boxes should upgrade the efficiency of the disassembly/reassembly process while satisfying the need for inventory control.

Findings: 38C's Interdependence with Primary AWCs

Although in any given case it is possible that a large number of work centers will assist 38C in the repair of a pump, the focus of the present study is on the Electrical Repair Shop (51A), the Electroplating Shop (51C), and the Sound Vibration Analysis Shop (92A) of the Electrical Branch and the Machine Shop (31A) and Metal Buildup Shop (31M) of the Machinery Branch. The focus of our discussion will be the repair of close coupled pumps, which represent 60 percent of 38C's workload. The remainder of 38C's workload is made up of coupled pumps, the repair of which presented no problems beyond those encountered in the repair of close coupled pumps.

The discussion begins with a description of the initial pump repair process for close coupled and coupled pumps followed by identification of problems and recommendations for each involving: (1) the internal work system of the Electrical Branch (51A/51C/92A), (2) coordination between 38C and the Electrical Branch, and (3) coordination between 38C/51A and 31A/31M.

The Pump Repair Process

Two types of pumps, close coupled and coupled, are brought to the shop for repair.

Repair of Close Coupled Pumps. In the case of the close coupled pumps, the motor and pump come into 38C for repair as a single unit because they share the same shaft. This type of pump usually required all of the work centers listed above to assist in the repair process (Figure 1). Once the pump was disassembled, various parts were sent to AWCs by any one of a number of paths depending on the nature and extent of the work required. The motor was usually handled in the following way:

1. The motor was delivered to the Electrical Branch (EB) where it was received, tested, pre-measured, and cleaned by several groups of workers in 51A.

2. The motor was assigned to one of three work sections which disassembled it.

3. If the stator required rewinding, it was given to a separate group of specialists in 51A.

4. Those parts which required electroplating were sent to 51C, a separate AWC within the EB.

5. Those parts which required assist from work centers in the Machinery Branch (e.g., squirrel cage, end bell) were delivered to 51A's Receiving group for logging in and distribution.

6. When metal build-up was required prior to machining, a member of 51A's Receiving group delivered the part first to 31M, picked it up on completion and delivered it to the appropriate planner in 31A. If metal build-up was not required, the part was delivered directly to 31A's planner. Once the machining was completed, 51A Receiving personnel picked up the part and returned it to the shop.

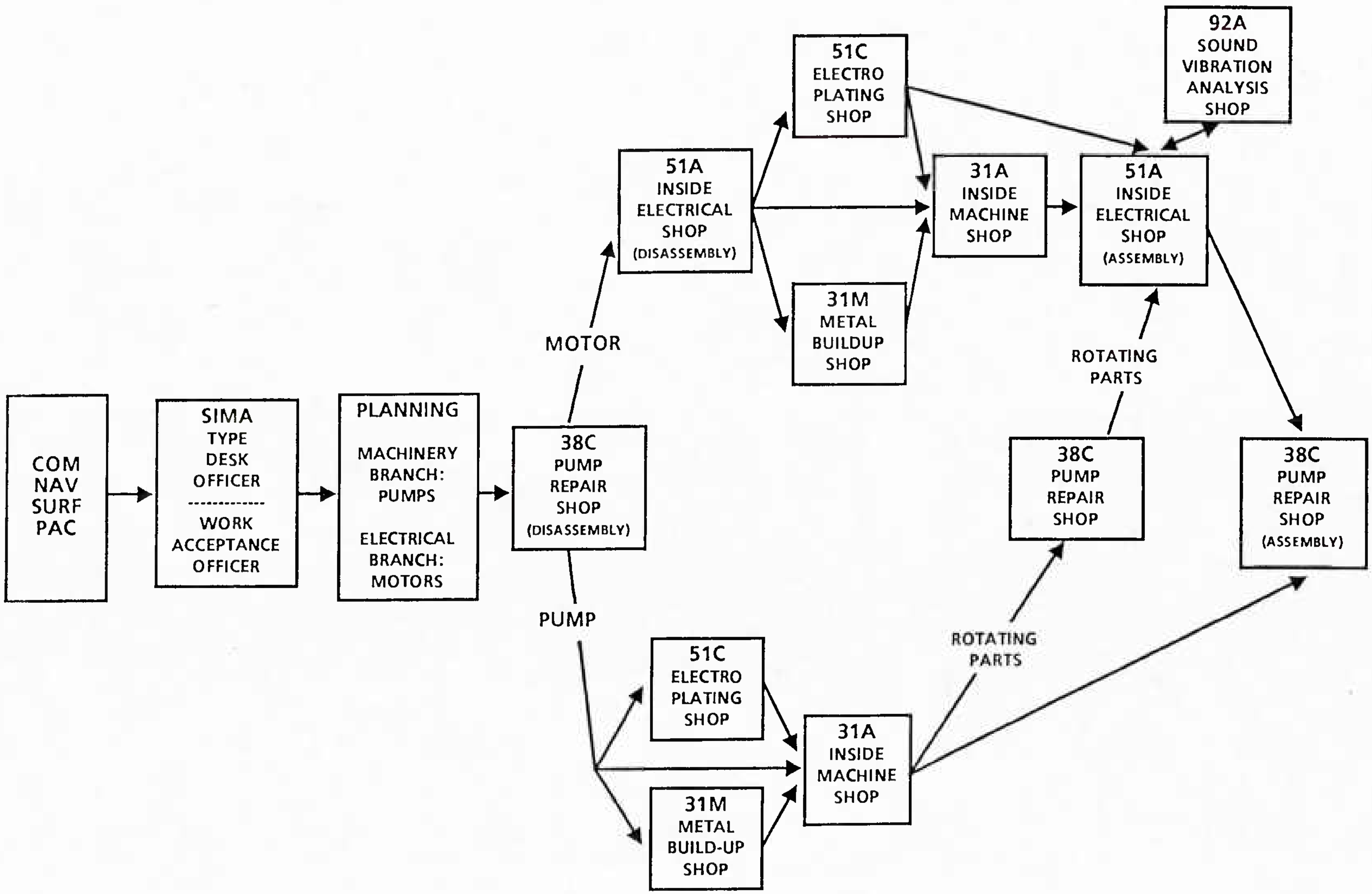

FIGURE 1. BASIC ELEMENTS OF REPAIR PROCESS FOR CLOSE COUPLED PUMPS

7. Upon notification, the work section assigned to the motor retrieved the parts for reassembly. It collected all the parts which had been processed by the Machinery Branch from 51A Receiving, the rewound stator from the specialist group, and those parts which required electroplating from 51C.

8. After processing by 31A the rotating parts were delivered to 51A Receiving by a team member from 38C. The assigned work section in 51A then picked up the rotating parts from Receiving, assembled them, and delivered them to 92A for balancing.

9. After balancing of rotating parts, the motor was reassembled by the work section and returned to 92A for sound and vibration testing as a final step in quality control (QC).

10. If the motor passed QC by 92A, it was returned to the work section for cosmetics.

11. Upon completion, the motor was delivered to QA where final inspection was performed, often in the presence of representatives of 38C.

At the same time as the motor was being delivered to EB, parts of the pump (e.g., rotating parts, pump casing and bearing housing) were being sent from 38C to the AWCs in its own Machinery Branch. The following sequence of events relating to the pump itself usually occurred:

12. When metal build-up was required prior to machining, a member of the 38C team assigned to the pump delivered the part first to 31M, picked it up on completion, and delivered it to 31A. If metal build-up was not required, the part was delivered directly to 31A. In either case a pump repair team member provided instructions to the planner in 31A. Once the machining was completed, the team member picked up the parts and distributed them accordingly. Rotating parts (e.g., impeller, wearing ring) were delivered to 51A Receiving by the 38C team member (step 8). All other parts were returned to 38C.

13. After all the parts were retrieved from machining and the motor received from 51A, the motor and pump were reassembled, inspected, and tested prior to QA.

Within 31M and 31A the following sequence of events occurred in relation to pump parts received from either 51A or 38C:

14. In the case where metal build-up was required, parts from either 38C or 51A were picked up from 31M and delivered to the appropriate planner in 31A. If metal build-up was not required, 31M was eliminated from the sequence.

15. All of the above mentioned parts of pumps, whether they originated from 38C or 51A, were received by the same 31A planner. They were logged in and a completion date for 31A's processing negotiated and approved by the head planner.

16. The work was then assigned to the first of the four 31A sections, depending on the sequence of operations required. The structure of 31A was functionally based, consisting of lathing, milling, and grinding sections in addition to quality control.

17. The head planner twice daily reviewed the progress of all the work in each section of 31A, relaying changes in priority to section foremen and tracking whether each job was on schedule.

Repair of Coupled Pumps. There was nothing new of significance in the repair of coupled pumps. Except for some parts that differed, all of the events associated with repair of close coupled pumps applied to coupled pumps except for involvement of 51A and 92A (Figure 2).

Problems Associated with Close Coupled Pumps

Repair of motors from close coupled pumps by the Electrical Branch AWCs involved extreme fractionation of the work. In 51A one group was responsible for (a) receiving the motor, (b) conducting initial electrical tests of it, and (c) overseeing parts delivery and pick-up. A second group was responsible for disassembly, cleaning, and reassembly. A third group was responsible for rewinding. Another group assigned to a different shop (51C) was responsible for pre- and post-measurement of parts. A second group in 51C was responsible for electroplating. Finally, a group assigned to another shop (92A) was responsible for balancing, sound analysis and vibration testing.

This division of labor in the EB caused a set of interrelated problems that can be grouped into three categories: (1) EB's internal work system, (2) coordination between 38C and the EB, and (3) coordination between 38C/51A and 31A/31M.

Problem: EB's Internal Work System. The extreme fractionation of work in the EB created numerous problems. First, tracking parts within 51A and between 51A and 51C/92A required an excessive amount of time and effort that could cause general confusion and result in coordination problems regarding parts in-house and produce delays in moving completed work from one station to another. Ultimately, deadlines were difficult to meet.

Work motivation was affected by this division of labor. Fractionation resulted in individuals working on only a small portion of the total job required to repair a motor. As a consequence, there was a lack of identification by workers in the EB with the ultimate product of their work, close coupled pumps. This problem was so pervasive in its effect that workers even lacked close identification with the intermediate product, the motor.

Finally, the extreme division of labor caused problems in personnel training and skill development. As in the Pump Shop, the EB of SIMA faced a continuous training requirement because incoming personnel were seldom thoroughly trained in the skills required for electrical motor repair. Unfortunately, the present division of labor did not support comprehensive training. Separating individuals into specialized groups prevented their gaining hands-on experience in the complete repair process of electrical motors. In the long run, the Fleet lost the opportunity to have more thoroughly trained personnel.

Problem: Coordination Between 38C and the EB. 38C was and is the lead work center for pump repair and as such is responsible for delivery of the repaired pump by an assigned completion date. To accomplish this, it was necessary for 38C team members to track the progress of work on all pump parts through the multiple AWCs. In the case of motors associated with close coupled pumps, the fractionation of work in the EB hindered 38C's tracking capabilities. Often a 38C team leader or delegated team member spent considerable time identifying which group in EB (e.g., rewinding, electroplating, pre- or post-measurement) was working on which part of a job in order to determine whether the

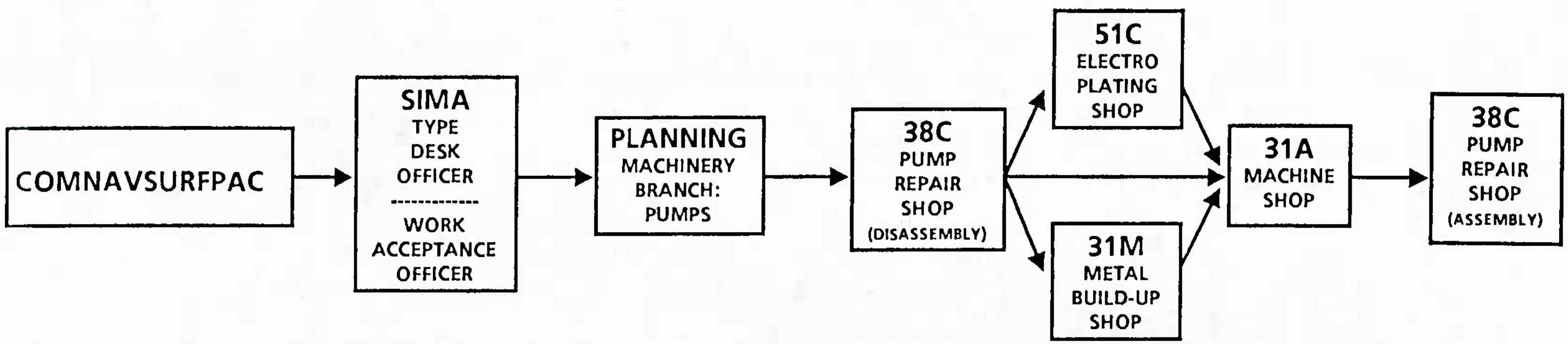

FIGURE 2. BASIC ELEMENTS OF REPAIR PROCESS FOR COUPLED PUMPS

completion date remained realistic. This information was also necessary for 38C to schedule pick-up of rotating parts from 31A and subsequent delivery of those parts to 51A in a timely manner.

Further complicating the coordination between 51A and 38C was their reliance on different information systems. For approximately a year 51A had been experimentally using an engineered time value (ETV) system. This provided 51A with two information systems: ETV and the centralized SIMA job order material status report (JOMS). JOMS provided 51A with 38C's completion date for the pump and ETV provided them with a completion date for their assist on a given job. Shop 38C, on the other hand, had access to only one information system, JOMS. Shop 51A eventually focused on ETV as its primary source of information, whereas 38C relied only on JOMS. When adherence to deadlines became an issue, only 51A knew its own completion date and the overall completion date for the job.

These coordination problems, that is, the tracking of work and the accessing of scheduling information, caused a deterioration in the relationship between the two shops. It was often frustrating for 38C team members to track work in progress. This process of information-gathering could easily be perceived by members of 51A as pestering, reflecting a lack of confidence in their ability to complete work on time. As a consequence, poor attitudes developed on the part of some of the people involved. This resulted in poor interpersonal relationships and degraded intershop communication.

Exercise. Propose a structure (job and organization design) that addresses the problems identified in EB and in EB's relation to 38C.

Researchers' Recommendation: EB's Internal Work System and Its Relation to 38C. The system of motor repair in the EB, excluding 92A, should be reorganized into multiskilled work teams given complete responsibility for the repair of electrical motors from close coupled pumps. Each of these teams should be aligned with the teams in 38C having responsibility for the particular pumps from which the motors have been detached.

An exception to the above recommended reorganization within EB concerns the Sound Vibration Analysis Shop (92A). Due to the specialized equipment involved, the training requirements for personnel, and 92A's ability to perform its role without causing any apparent bottleneck, the shop should remain a specialized AWC.

Rationale. There were enough qualified personnel in EB at the time of the study to form teams capable of performing all the required tasks (e.g., pre- and post-measurement, electrical tests, rewinding, electroplating) with minimal additional training. Furthermore, none of the tasks required extensive training. Therefore, additional multiskilled personnel could be developed in a reasonable time period through on-the-job training.

The effect of this reorganization should be widespread, benefiting the Electrical Branch, 38C, SIMA San Diego, and the Pacific Fleet. From the point of view of production, efficiency should increase because of time savings from improved coordination. Less time will be spent tracking parts in EB and less time lost due to moving of parts between work groups. The coordination between EB and 38C will improve by having associated team members communicating directly with one another and by simplifying 38C's tracking of parts, resulting in improved interpersonal relations between the two branches.

Coordination of work should also improve between EB and 31A with team members from EB communicating directly with the planner in 31A to obtain necessary information. The reorganization should eventually lead to EB team members picking up rotating parts directly from 31A without 38C playing an intermediary role.

The reorganization should also have positive impact on motivation, morale, and product quality. EB team members will be completing a whole and identifiable piece of work that lets them develop some pride of ownership that should result in a product of higher quality. Furthermore, alignment of EB with 38C teams establishes an identification with the ultimate end product of the work, close coupled pumps. Direct communication and coordination between EB and 38C teams should result in improved interpersonal relationships and a spirit of "pulling together" in the repair of close coupled pumps.

Lastly, there are training benefits to be derived from the reorganization. Team members from EB will have the opportunity to become skilled in all of the tasks required for electrical motor repair. This should boost morale, lead to improved performance, and, in the long run, provide the Fleet with a more valuable, highly trained work force.

Action and Discussion--EB's Internal Work System and Its Relation to 38C. Fourteen electricians (E3 - E8) were transferred from the Electrical Branch to the Machinery Branch to work with 38C teams. They work as a team and have responsibility for the entire process of overhauling pump motors. Electrical Branch assistance is now only required for electroplating, occasional rewinding, and balancing, each of which was felt by management to require specialized skills or equipment. The decision has also been made by the task force to build electroplating capability within the Machinery Branch, probably in 31M. Ventilation and plumbing are being installed in the building which houses 31A/31M and equipment is being transferred from the EB. Upon completion, the 38C electricians will take over control of their electroplating requirements.

These changes improved Machinery Branch control over the activities required to repair close coupled pumps and eliminated most interbranch problems. Training for electricians was also upgraded to include comprehensive experience in overhauling the full variety of close coupled pump motors. Both quantity and quality of output are expected to benefit from workers who are more highly motivated because of close identification with the end product.

Problem: Coordination Between 38C/51A and 31A/31M. The fractionation of work in 51A, besides its negative impact on relations between 38C and 51A, also had a negative impact on the coordination between 51A and 31A/31M. The section in 51A assigned the motor did not track its own parts when they left the EB. This was done by a member of the Receiving group. Such displacement of tracking responsibility creates time and communication problems by adding another link to the communication chain. There was a built-in time lag when the section dropped off a part with Receiving for delivery to either 31M or 31A. A similar time lag was created when the part was brought back to the EB from 31A/31M by Receiving, and the lag was further extended in communicating this information to the originating section of 51A.

This communication problem extended further in two directions. First, to the member of 38C who was tracking parts in 51A, the division of labor among diverse work groups presented an extremely long and complex trail to follow. Second, required coordination between 51A and 31A regarding work specifications and schedule was conducted by a member of 51A's Receiving group and the planner in 31A. Thus, a member of Receiving was representing the 51A section responsible for the motor. This increased

the possibility of poor coordination regarding deadlines and priorities and poor intershop communication regarding work specifications.

Finally, 38C received direct assistance from 31A in the form of a wide range of machining--some pumps required only turning of a wearing ring, others required production of an entire shaft. Machining services were provided to the entire SIMA organization by 31A, with 50 percent of its workload originating in 38C. Internal scheduling of work in 31A was performed on an individual part basis according to when the parts arrived at the shop. Parts related to the same product had different dates of completion. This caused problems in coordination between 38C and 31A in tracking work in progress and in accounting for all parts associated with each pump in a timely manner.

Exercise. Develop a set of changes in organization structure and functioning to improve the effectiveness of 31A in the system of pump repair.

Researchers' Recommendation: Relations Between 38C/51A and 31A/31M. Shop 31A should be reorganized into pump and non-pump clusters, each comprised of lathe, milling, and grinding sections which would service specific products.

If implementation of recommended changes results in an increase in pump repair output, the number of personnel in 31M should be adjusted and investment in their training made to insure an adequate supply of certified people.

Rationale. Reorganizing 31A into parallel shops to service specific products will improve both the scheduling and the tracking of work in progress within the shop and benefit the entire system of pump repair. It would enable 31A planners to establish a common schedule for all of the work required on a particular pump. Furthermore, it would enable the shop floor supervisors (chiefs and senior chiefs) to monitor the progress of all parts associated with a specific pump across all necessary machining operations. This change should result in improved coordination, in better schedule adherence, and in greater identification by members of 31A with the product as they come to understand their role in the system of pump repair.

Action and Discussion--Relationship of 38C/51A and 31A/31M. The work acceptance process in 31A was redefined to schedule and track work by product; however, the shop was not reorganized into product groups. By using the existing "planner" role, incoming work was divided equally between two planners according to shop origin--one planner serving 38C (pumps and motors) and the Electrical Branch and the other serving the rest of SIMA. To speed up material and parts ordering and scheduling procedures in 31A, team leaders in 38C are responsible for informing 31A planners of all machining assistance required as soon as the pump is opened up. When the parts are delivered to 31A the planner is responsible for issuing them and monitoring progress through the lathe, grinding, and milling sections. He also expedites the work, as necessary, to assure completion of all components of a specific pump on time.

The sole resistance to reorganizing the shop into product clusters came from the shopmaster and his shop floor supervisors who insisted that little, if anything, would be gained and that such redesign would impose unnecessary problems in regard to the use of equipment and personnel. His apprehension was not shared by other knowledgeable senior officers and staff civilian personnel specialists. The researchers have reason to believe that the real resistance regarding the redesign into product clusters came from the shop floor supervisors who were accustomed to supervising specific machining operations, that is, lathing, milling, or grinding, and not being accountable for all of the machining

operations required for the completion of the job on a specific product. Given their concern, the decision was to implement change in 31A slowly, beginning with the redefinition of the role and function of the shop planners. It is likely that the issue of redesigning the shop into product clusters will be reconsidered in the future if 31A is not capable of keeping up with the expanded capacity of the pump repair system.

Findings: SIMA Support for the Pump Repair Process in 38C

The process of pump repair requires a wide range of support from SIMA including planning, scheduling, technical documentation, procurement of materials and supplies, management information, and liaison with the Fleet. Although all of these functions were possible candidates for improving pump repair effectiveness and efficiency, it was the decision of the researchers and the task force that most benefit would be derived by focusing upon three important areas: (1) planning, (2) technical documentation, and (3) supplies.

Planning Pump Repair

Problem. SIMA had a centralized Planning Department. Approximately 45 days prior to the start of a ship's availability with SIMA, planners prepared a job order based on the automated work request submitted by the ship. They verified the identification of the pump (by physical inspection, if possible), gathered technical documentation (prints and manuals), initiated procurement of parts, set a completion date, and forwarded the assembled work package to 38C, with copies of the job order to all AWCs. When revisions were required based on shipboard inspection or pump disassembly, paperwork flowed back to the Planning Department for processing before being returned to the shop to activate work. This process caused a three- to four-day delay, which was often critical in meeting a ship's requirements for job completion. Delays also occurred with emergent work due to processing required by the Planning Department. Furthermore, for a variety of reasons there was considerable duplication of effort by planners and 38C production personnel in the performance of ship checks, retrieval of technical documentation, and ordering of parts and material.

Exercise. Recommend changes in the way SIMA carries out its planning function to ameliorate problems of delays and loss of productive time.

Researchers' Recommendation. A new role, shop planner, should be created in 38C. Four persons, two from the Planning Department and two from 38C, should be trained in planning and pump repair processes and given responsibility and authority to carry out planning functions for revisions and emergent work required after the beginning of the ship's availability period. To accomplish their role shop planners must work with team leaders to decide jointly how to handle work requiring revisions.

Rationale. This division of planning responsibility eliminates time delays and duplications of effort, while giving shop planners on-site exposure to the complex process of pump repair and direct access to up-to-date information regarding shop workload, typical problems, and ways to facilitate the repair process. At the same time, the pump repair teams have direct, convenient access to planning assistance.

Action and Discussion. The recommendation was accepted and implemented in the following manner: Two 38C personnel were selected and detailed to the SIMA Planning Department for one month of training. They, along with two members of the Planning Department, were then detailed to 38C for a three-month trial period. The three-month

review was positive with the result that the role of shop planner was continued in 38C with the four shop planners permanently assigned to the Machinery Branch.

Technical Documentation

Problem. Technical documentation in the form of manuals and blueprints is required by the pump teams in order to obtain specifications and tolerances as well as to provide a guide for overhaul. The responsibility of obtaining documentation from the Technical Library was assigned to the central planners; however, it was often necessary for repair personnel to invest considerable time in seeking alternative or additional manuals or prints to meet their needs. This duplication of effort occurred because several sets of documents or drawings were often required for particular pumps and the planners, unfamiliar with the pump repair process, were incapable of making accurate decisions regarding which ones to provide the teams. Also, once the pump was disassembled the reality at hand often forced repair personnel to seek additional information.

Exercise. Given the changes described up to this point, recommend a way of reducing the time production workers spend in obtaining necessary technical documentation for pump repair.

Researchers' Recommendation. The shop planner should procure all technical documentation supplemental to that provided by central planners in the work package. The shop planners should work with the pump teams to identify additional documentation and then with the technical library personnel to locate and retrieve materials for loan to the shop. The shop planners should also establish on the shop floor a small working library of technical manuals and blueprints for the more frequently repaired pumps. This documentation could be acquired through the library which can replace it through reorder.

Rationale. This change will enable team members to have input into what kind of technical documentation they need without requiring them to find it. It will also assist in training planners and furthering their understanding of the pump repair process. Finally, it will enable the Pump Shop to develop a small technical library so that the manuals and blueprints most often used will be readily available in the shop.

Action and Discussion. This recommendation was implemented as part of the development of the role of shop planners in 38C. It was progressing successfully after the three-month trial period and is presently part of on-going shop planner activities.

Supply Support

Problem. The parts and materials necessary for the pump repair process are procured through a central supply operation in SIMA which has interface with the Navy supply system and functions according to Federal and Department of Defense procurement regulations. Generally, 38C is required to work within a tight schedule dictated by the Fleet. Although supply personnel provide on-going assistance in obtaining parts, 38C has traditionally assigned production personnel to handle supply tasks because of tight scheduling. These personnel handled paperwork, tracked orders, picked up deliveries, and acted as supply petty officers to manage small inventories of "pre-expended bin" (PEB) items and stockpiled leftovers from previous jobs. This diversion cut into production time and burdened the pump repair teams, the shop, and the branch.

Exercise. Given the realities of the larger supply system, are there any changes which can be made within SIMA to ameliorate the problems noted above?

Researchers' Recommendation. A satellite supply store should be established within the building occupied by 38C, the Electrical Branch, and Valve Shop (building 3278). This store should serve all shops in the building, assuming responsibility for inventory control for Electrical and Machinery Branch PEB programs and stocking as much as possible of low cost, high volume parts and materials that are used exclusively in the building. Present unauthorized stockpiles of parts should be absorbed into the store or main supply or sent for disposal. Personnel to operate the store should be drawn from two sources: (1) Electrical, Valve, and Pump Shop personnel who are performing similar functions and (2) Supply Department personnel.

Rationale. Through improved inventory control the store could expand the assortment of items available. The shops should experience a reduction in personnel assigned to a supply role as well as a reduction in space requirements for parts handling due to elimination of stockpiles. In addition, the store will provide a local point of contact for shop personnel with the SIMA supply system, while relieving the shop of the burden of non-productive use of pump team personnel by substituting a small number of persons (shop planners) to learn and carry out the interface role with the satellite supply store.

Elimination of duplication of functions among shops and the establishment of a professionally operated satellite supply store should result in greater overall efficiency in personnel utilization, with some billets "saved." In addition, use of a mix of shop and Supply Department personnel should provide opportunity for cross-training of personnel as they work together, exchanging technical knowledge about both pumps and pump repair and supplies and procurement procedures.

Action and Discussion. The concept of the satellite supply store was approved for implementation after the Supply Officer conducted a feasibility study. Development of the store is to be accomplished in two stages: During the initial stage the Supply Department will assume responsibility for inventory control of PEB programs in building 3278, set up the physical facility for the store, and begin its operations. These tasks include determination of parts and materials which could advantageously be stocked in the store, transferring and cataloging parts from unauthorized shop stockpiles, obtaining material storage equipment, and determining manning requirements. A later stage will involve processing supply requisitions in the satellite store, thus speeding up response time for obtaining parts and materials. This is dependent on Navy-wide adoption of SUADPS-RT, an automated, uniform supply processing system which is expected to be on-line by FY86. However, expediting will still continue to be centralized due to dependence on various electronic assists and data bases.

Findings: Physical Plant Layout and Space Allocation in Building 3278

Problem. Building 3278 is a modern two-story industrial building divided between the Electrical and Machinery Branches. The Pump Repair Shop occupies about 25 percent of the first deck along with the Valve Shop, the Auxiliary Shop, the Machinery Branch offices, and part of the Inside Electrical Shop. The second deck is shared by several Electric Branch shops and the EB supply space, along with the Hydraulics Shop and supply space for 38C. The physical layout and space available for pump repair are inadequate and include the following conditions:

1. Insufficient work space due to a 70 percent increase in pump repair production and associated manning over the previous 18 months.

2. Insufficient storage space for work in progress due to increased pump production and the presence of motors from close coupled pumps.

3. Insufficient space for locating new equipment (e.g., a larger sandblaster) for both pumps and motors.

4. Insufficient space to locate electricians involved in pump motor repair near pump repair teams.

5. Insufficient space to locate shop planners, along with their tools and equipment, near pump repair teams and electricians.

6. Additional space was required for the satellite supply store.

Researchers' Recommendation. Vacate some space on the first and second decks of building 3278 by moving out less critical shops and reassigning the first deck as work space for the 38C electricians, shop planners, and pump teams, and as space for storing work-in-progress and new equipment. Space on the second deck should be used to establish the satellite supply store.

Rationale. The initial floor plan of building 3278 is shown in Figure 3. Among the Machinery Branch shops occupying building 3278, two are desirable candidates for relocation: the Auxiliary Shop (38D) and the Hydraulic Shop (31F). The first deck space occupied by 38D would be highly desirable to locate 38C electricians because it is adjacent to the Pump Repair Shop while allowing access to large equipment in the Electrical Branch necessary for motor overhaul. A relatively large, underutilized space on the second deck could be used for the satellite supply store by relocating 31F. Relocation of 38D and 31F is possible on completion of a new building (3339) near 3278. The new facility has space suitably located and equipped for 38D with adjacent space which could be developed to suit the requirements of 31F. Co-location of these two shops should facilitate utilization of 31F personnel by 38D when their own workload is insufficient.

Action and Discussion. Figure 4 shows the reallocation of space in building 3278 vacated by 38D and 31F. Pump Shop electricians and shop planners were allocated additional work and equipment space. The small sandblaster was removed, expanding the pump repair work space, and a larger sandblaster installed in a central location. The Air Conditioning and Refrigeration Shop was given a small area due to its displacement from other quarters. An expanded storage area for pumps and motors was identified and vertical storage equipment ordered. The space in the Electrical Branch receiving area vacated by the 38C electricians was returned pending decision about its importance to the satellite supply store in meeting weight constraints on the second deck.

The area vacated by 31F on the second deck was allocated to the Supply Department to be developed into the satellite supply store. The present 51A supply space will be returned to production use once the satellite supply store is operational.

A Sociotechnical Systems Perspective of the Findings and Change Recommendations

The change to work teams in 38C had positive effects on productivity (see Table 1). However, complementary changes in the structure and functioning of AWCs and SIMA

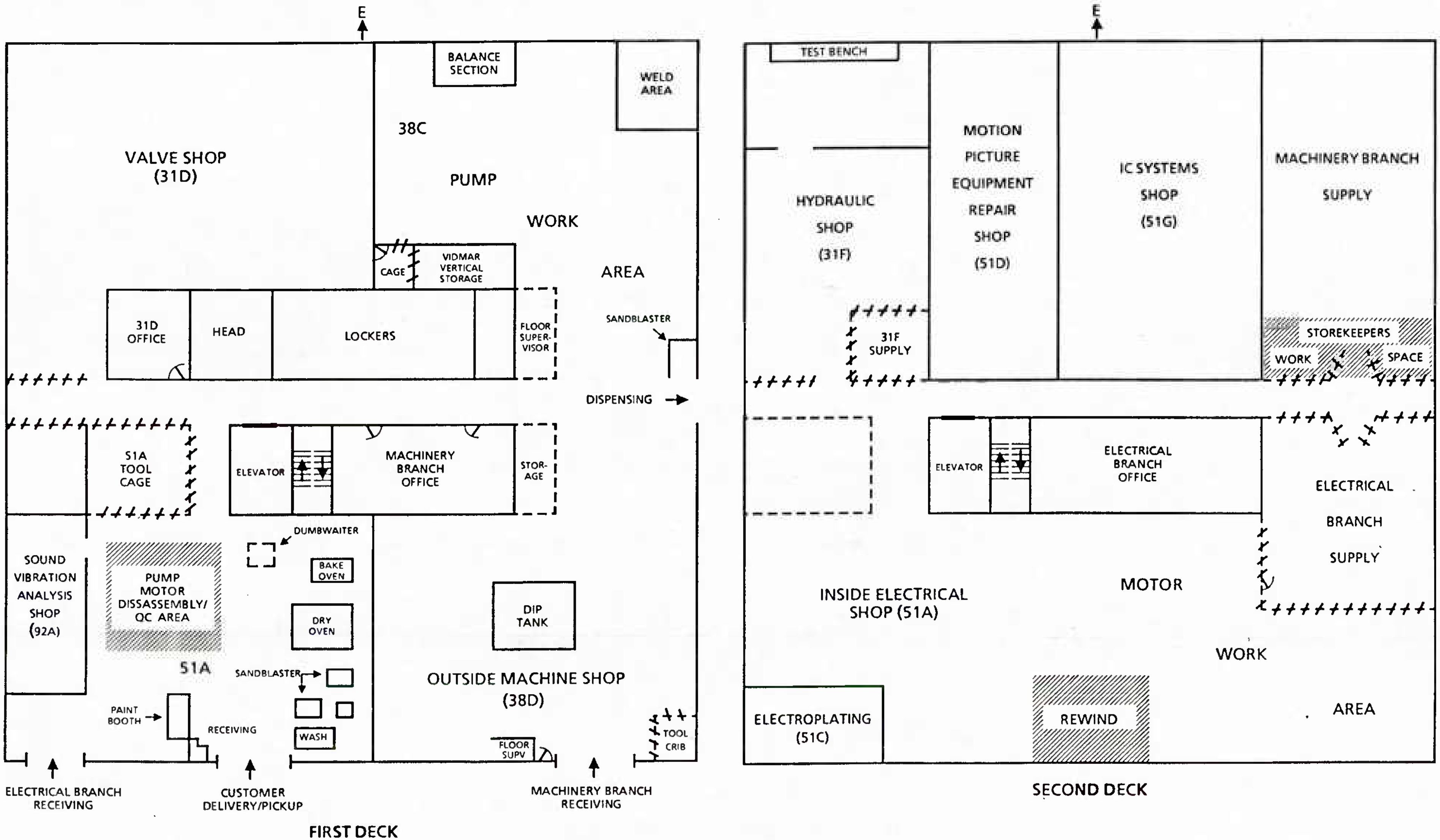

Figure 3. Building 3278 floor plan prior to reallocation of space.

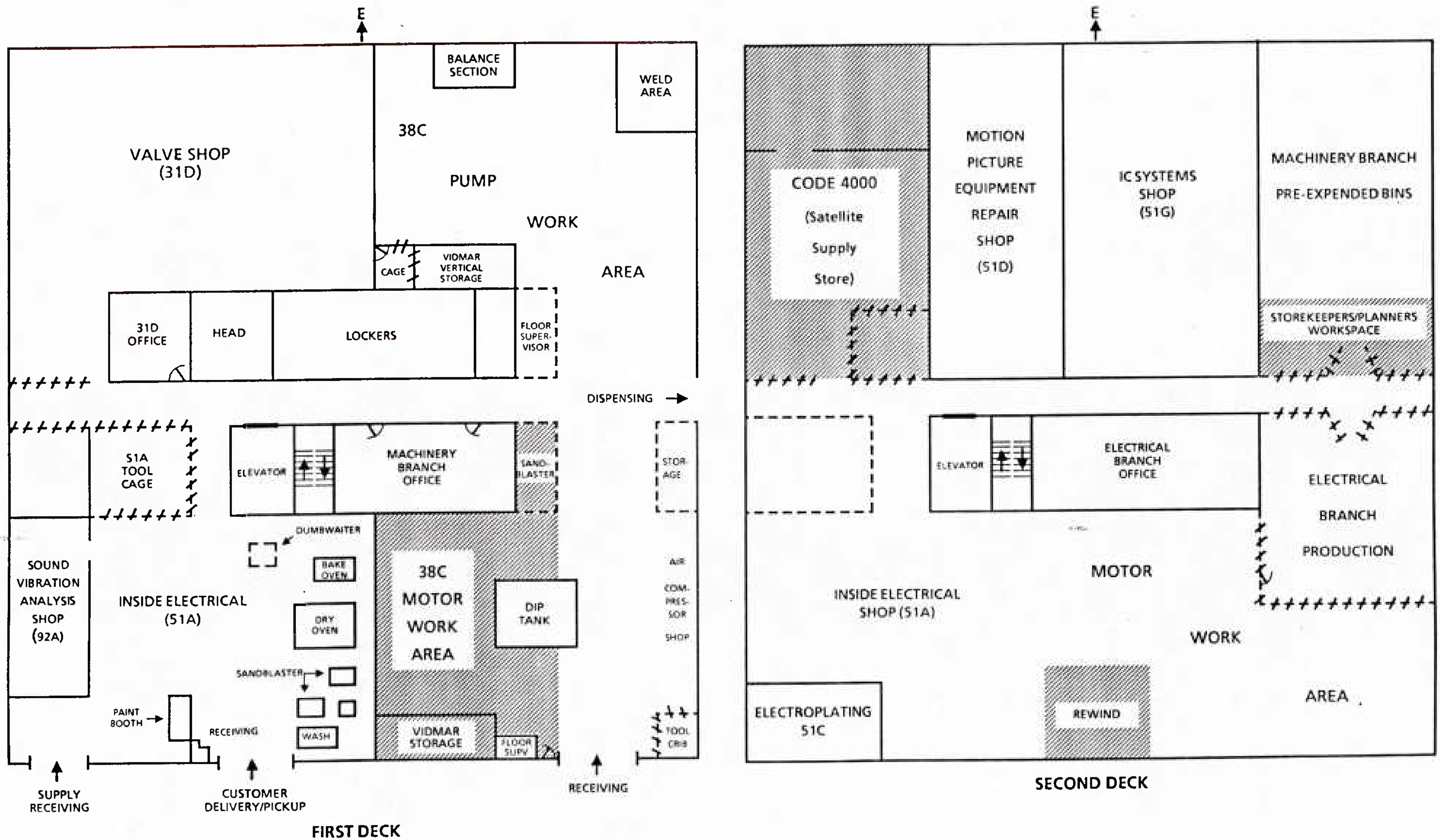

Figure 4. Building 3278 floor plan after reallocation of space.

staff functions were not made at the same time. This omission hindered the ability of the shops involved in pump repair to realize their potential and threatened the long-term viability of the organizational improvements in the Pump Shop. The goal of the changes was to give 38C greater control over the events and activities that support pump repair. This was accomplished through redesign of the boundaries associated with the product (inclusion of close coupled pump motors) and reduction of the shop's dependence on staff support functions (decentralization of planning and procurement). In terms of open systems theory, these changes increase self-management on the part of pump shop repair teams (Emery & Trist, 1960; Katz & Kahn, 1966). From the perspective of design, the changes are intended to optimize shop-organization design by creating a complementary organization structure to support production system functioning (Davis, 1979). The problems identified and corrective actions taken are discussed below in terms of sociotechnical system design principles. They are summarized in Table 3.

Changes Within 38C

The initial change in the work system design in 38C was made by the incoming branch officer from one of functionally specialized sections to one comprised of teams responsible for the overhaul of assigned pumps. With the involvement of the researchers, the team-based design was augmented by changes in the performance measurement and feedback system, the acquisition of tools and equipment, and preparation for shop-level management orientation and supervisory training. These changes within 38C can be understood in terms of the sociotechnical concepts and principles outlined earlier.

The initial change to teams violated the principle of compatibility. The branch officer conceived the idea of teams and implemented them by exercising command prerogative. None of the pump shop members participated in the formulation of the team concept. Despite this, a number of sociotechnical principles were satisfied through the change to team-based organization. The teams were given broad responsibility and they became self-managing in their pump repair activities, thus satisfying the criterion for minimal critical specification. Variance control was partially accomplished by the change to teams, although control of motor repair for close coupled pumps (which represented 60% of the work) remained with the EB. Even with the change to work teams, the Pump Shop and its members were still dependent on the Planning and Supply Departments to respond to revisions and emergent work, to obtain technical documentation, and to procure materials.

The principle of boundary location was partially addressed by the change to teams. In terms of time (i.e., work completed on the same shift without built-in time delays), territory (i.e., co-location of required personnel and resources), and technology (i.e., immediate availability of required knowledge, skills, and equipment), the pump teams had within their boundaries the capacity to control the operations required to overhaul coupled pumps; however, this was not the case for close coupled pumps whose motors were repaired in the EB. Furthermore, SIMA support in terms of planning and supplies was not integrated within the pump shop boundary in terms of either time, territory, or technology. This became critical when the Pump Shop had to respond to revisions and emergent work.

Regarding information flow, an attempt at decentralization of relevant production information was partially successful through the team design. However, teams still remained highly dependent on AWC schedules and centralized planning. The principle of support congruence was satisfied through the new shop-designed performance measurement and feedback system which provided teams with an equitable system of recognition.

Table 3. Sociotechnical Analysis of Changes in the System of Pump Repair

Sociotechnical Principles	Changes Within 38C	Changes Between 38C and AWCs	Changes Between 38C and SIMA Support	Changes in Layout/Space
Compatibility	Initial change to teams in 38C carried out by directive	Collaborative problem identification 51A and 31A recommended action to be taken	Collaborative problem identification Planning and Supply recommended action to be taken	Collaborative problem identification SIMA management recommended action to be taken
Minimal Critical Specification	Pump team self management	Electrical group self management	Self management by shop planners	
Sociotechnical Criterion (variance control)	Partial: complete for coupled pumps; not for close coupled pumps	More complete: all except electroplating of close coupled pumps	Complete: including shop planners for revisions and emergent work and Satellite Supply Store	
Multifunctional Principle	Multiskilled pump team members	Multiskilled electrical group members	Multiskilled shop planners Cross training of production workers and supply workers in Satellite Supply Store	
Boundary Location	Partial control: complete for coupled pumps; close coupled pumps not integrated by territory	More complete control: close coupled pumps integrated by time, territory and technology	Complete control: planning for revisions and emergent work, technical documentation and supplies integrated by time, territory and technology	Complete control: adequate space to integrate all changes by time, territory and technology

Table 3. Sociotechnical Analysis of Changes in the System of Pump Repair (Continued)

Sociotechnical Principles	Changes Within 38C	Changes Between 38C and AWCs	Changes Between 38C and SIMA Support	Changes in Layout/Space
Information Flow	Partial: attempt at decentralization but still dependent on AWC schedules and central planning	More complete: eliminated discrepancy between ETV and JOMS information systems	Complete: Shop level control of planning and technical documentation for revisions and emergent work	
Support Congruence	Pump shop-designed team performance measurement and feedback system	Feedback based on keeping up with pump teams	Feedback based on keeping up with pump and motor teams	
Human Implications	Team member pride in their responsibility for whole task	Electrical group's pride in and ownership of whole task	Shop planners' and Supply Storekeepers' pride in and responsibility for complex task accomplishment	
	Team member identification with product and ownership of results	Electrical group's identification with product	Shop planners' and Supply Storekeepers' identification with system of pump repair	
Incompletion	Supervisory training	Secondary AWCs	Further decentralization of planning	Satellite supply store: necessity of ground floor physical space
	Management orientation	31A product clusters		
	Cultural development	31M electroplating		

Team design enhanced motivation among repair personnel, because they felt pride in being capable of taking over total responsibility for the overhaul of a set of assigned pumps. This enabled team members to develop a strong sense of identification with the product and ownership for the results in terms of both quality and quantity.

Finally, the principle of incompletion is being addressed through current development of management orientation and supervisory training. This is both an effort to institutionalize the changes in the system and to develop an organizational culture that understands the nature of the pump repair process and supports its continued effectiveness by learning from experience and adapting the work system to environmental changes.

Changes in Relations Between 38C and its Primary AWCs

A major problem area with AWCs was in the coordination, scheduling, and tracking of work in progress on the electrical motors of close coupled pumps. Initially, pump overhaul required the Electrical Branch to act as an AWC for the repair of the motor. By transferring 14 electricians from the Electrical Branch to the Machinery Branch, 38C's control over activities required to repair close coupled pumps was improved and interbranch problems largely eliminated.

A second problem with AWCs occurred as a result of 38C's interdependence with the Machine Shop (31A). This shop provides machining services to the entire SIMA organization, with 50 percent of its workload originating in 38C. Internal scheduling of work in 31A was based on repair of individual parts rather than sets of parts for a specific piece of gear. This caused problems in 38C's tracking of work in progress and in timely delivery of all parts associated with a pump. These problems were overcome by redefining the role of work acceptance personnel in 31A to include responsibility for scheduling and tracking work by specific product.

The changes between 38C and its primary AWCs were made in accordance with the principle of compatibility. Researchers and key personnel from both the EB and the Inside Machine Shop (31A) engaged in collaborative problem identification. Once a consensus had been reached in regard to the nature of the problems, the personnel from 51A and 31A recommended the corrective actions to be taken.

The electrical group in 38C was given broad responsibility for repair of electrical motors, consistent with the principle of minimal critical specification. Their exercise of self-management in working with the pump repair teams operates to build self-esteem and a sense of responsibility. Moving the electricians into the Machinery Branch gave the Pump Shop control over the variance associated with operations required to overhaul close coupled pumps. These changes, in part, also addressed the multi-functional principle. The formation of an electrical group developed members with multiple skills in the repair of electrical motors. This was not achieved in 31A, which remains functional in design with workers and supervisors continuing to specialize in particular machines.

Incorporating electricians into the Machinery Branch improved the boundary location associated with pump repair operations as close coupled pumps became integrated by territory, as well as time and technology, into the Pump Shop. The move of electricians also improved information flow by eliminating ETV as a way of monitoring the repair of motors associated with close coupled pumps.

The 38C electrical group receives performance feedback based on its capacity to keep up with pump team requirements (support congruence). Electrical group members

took pride in their overhaul of all motors associated with close coupled pumps. Furthermore, their co-location with the pump teams provided them with clear feedback about their importance to the pump repair system and led to their identification with the finished product (human values).

Finally, the principle of incompletion can be said to be satisfied in terms of potential future developments in the pump repair system. Over time, managers and production personnel should be able to determine whether or not it is necessary and possible to integrate secondary AWCs into the team-based pump repair system. Also, time will tell whether or not development of 31A into product clusters may be required.

One example of learning over time is the progress being made toward developing a site within 31A/31M to provide the Machinery Branch with its own electroplating capability to further its control over repair operations.

Changes in Relations Between 38C and SIMA Support

Problems between 38C and SIMA staff functions were also identified. Critical time delays due to required revisions in planning or additional planning for emergent work were dealt with by decentralizing a portion of planning. This was accomplished by creating a new role, shop planner, in 38C. Four persons were given responsibility and authority to carry out planning functions for revisions and emergent work, thus eliminating associated time delays.

Other problems occurred due to the centralized supply system. The shop was required to work within a tight schedule dictated by the fleet. To facilitate timely parts procurement, 38C diverted production personnel to handle paperwork, track orders, pick up deliveries, and act as supply storekeepers to manage small inventories of PEB items. This problem was addressed by creating a decentralized, professionally manned satellite supply shop located in the building which housed pump repair operations.

Changes between 38C and SIMA support functions were made in accordance with the principle of compatibility. The researchers and key personnel from the Planning and Supply Departments worked collaboratively to identify important problem areas and recommend the corrective actions to be taken. Once the shop planners were trained and detailed to the Machinery Branch, they became self-managing in carrying out a broad range of responsibilities, thereby meeting the criterion of minimal critical specification.

The decentralization of planning and the establishment of the satellite supply store improved shop-level control of variance in pump repair operations. Shop Planners had the responsibility and authority to activate work on all revisions and emergent cases. The presence of a supply store in the same building eliminated time delays.

Some SIMA staff members became multi-functional. Shop planners acquired new skills as they were trained to carry out planning, technical documentation, and parts procurement activities. In the store, "cross-fertilization" of skills occurred between assigned production workers, who were familiar with the parts, and assigned storekeepers, who were familiar with the supply system.

The boundary of the pump repair system provided complete control of the pump repair process by 38C personnel with the changes in SIMA support functions. Shop planners responsible for revisions and emergent work, technical documentation and supplies were located close to the electricians and the pump repair teams, thereby

integrating these functions by time, territory, and technology into the system of pump repair.

Information flow was also improved by the changes in SIMA support functions. The information on planning and technical documentation became available at the shop-level to aid in revisions and emergent work. Shop planners experience support congruence through feedback concerning their ability to keep pace with the system of pump repair.

The people involved also benefited from these changes (human values). Shop planners could take pride in and responsibility for their complex task accomplishments. They could also recognize the importance of their role in the pump repair system. The same can be said for the personnel assigned to the satellite supply store.

The principle of incompletion also holds for SIMA support functions. The learning gained during this phase of the reorganization will determine whether it is necessary and possible to further decentralize the planning function.

Changes in Plant Layout and Space Allocation

It was necessary to reallocate physical space in the building to locate electricians and shop planners close to pump repair teams, to increase production space, and to decentralize supplies. This was accomplished by moving two repair shops out of the building into a newly constructed location.

The principle of compatibility was followed in the reallocation of physical space. The researchers worked collaboratively with key SIMA management to develop consensus regarding the nature of the problem and to generate alternative solutions, but SIMA management ultimately decided on the corrective action to be taken. The reallocation provided adequate space to accommodate all of the aforementioned changes to improve integration in terms of time, territory, and technology (boundary location).

The process of allocating physical space is an on-going, changing activity that expresses the principle of incompletion. Experience will determine whether or not it is necessary to allocate ground floor space in the building to the satellite supply store. This might be necessary either due to the volume of materials or weight limitations for the second deck.

PLANNING AND EXECUTING CHANGE

Method

The project was a collaborative effort between the researchers from NAVPERSRANDCEN and the management and staff of SIMA to diagnose present organizational functioning, identify problem areas, generate alternative solutions, critically evaluate and recommend preferred solutions, and facilitate implementation of approved changes.

These activities were carried out by a task force whose membership included the authors and a diagonal slice of organization members who had relevant knowledge of and responsibility for pump repair activities. The following organizational roles were represented:

1. Team leaders responsible for coordinating team activities in the repair of pumps.

2. Shopmaster responsible for coordinating all production activities in the Pump Shop.

3. Division Officer responsible for the administration of the Pump Shop (and later also the Machine Shop).

4. Branch Officer responsible for management of the Machinery Branch which included the Pump Shop.

5. Repair Officer responsible for overseeing daily repair activities throughout SIMA and interfacing with managers of ships serviced by SIMA.

6. Production Officer responsible for all production-related activities in SIMA.

7. Executive Officer responsible for production, administration, planning and scheduling.

8. Civilian Management Engineer responsible for production standards and the management information system.

Members from AWCs assisted the task force when their special expertise was required. Their organizational roles included:

1. Shopmaster of the Electrical Shop responsible for repair of electrical motors associated with pumps.

2. Division Officer responsible for administration of the Electrical Shop.

3. Electrical Branch Officer responsible for management of Branch activities including those of the the Electrical Shop.

4. Section foremen in the Machine shop responsible for supervising specific machining operations.

5. Shopmaster of the Machine Shop responsible for machine work required to repair components of pumps and motors.

Other task force members were associated with various staff support functions in SIMA. These included the following:

1. Several persons from the Planning Department: the Planning Officer, civilian head of planning, civilian supervisor of planning related to pumps, and several planners, all of whom were responsible for processing work requests and forwarding them to 38C.

2. Civilian Design Engineer responsible for technical drawings and manuals required for pump repair.

3. Supply Officer responsible for procuring parts and materials required for repairs.

4. Technical Library Supervisor in charge of acquiring and maintaining prints, drawings and manuals for equipment repaired by SIMA, San Diego.

5. Equipment Repair Manager responsible for maintenance and repair of shop equipment throughout SIMA.

6. Facilities Maintenance Engineer responsible for design and maintenance of SIMA shop facilities.

Structured and unstructured interviews, observation, and analysis of historical records were used by the researchers during the first phase of the study to gain an understanding of the pump repair process. Based on the findings of the initial phase, discussions among task force participants were used to develop solutions and build consensus prior to submitting recommendations for change to the SIMA CO for formal approval.

The Process of Change

The processes of analysis, development of detailed design proposals, and implementation of changes are shown chronologically in Figure 5. Several areas of analysis and change are discussed in detail below.

Analysis of the Pump Repair System

The study commenced with the researchers evaluating the team-based work system design in 38C and identifying areas for improvement in the system of pump repair. This was accomplished through a task force made up of the researchers and multiple informants (Figure 5a). The analysis of the pump repair system included a scan of the pump shop environment, an examination of the internal operations of the pump teams within 38C, and a look at the work relations between 38C and its primary AWCs.

The analysis took approximately two months and resulted in recommendations for a series of changes. The recommendations were initially reviewed by the management engineer and then presented to the CO at a formal meeting. The CO approved the actions recommended and sanctioned implementation of the changes, as discussed below.

Changes in 38C's Relationship with 51A

The integration of electricians into the Pump Shop was the first change accomplished in the pump repair system (Figure 5b). The way this change came about exemplifies one mode of change which can be used in a client system. The researchers called for the formation of teams in the EB to reduce the fractionation of work on close coupled pump motors. They further recommended that these teams be aligned with pump teams to integrate the work. After the CO's acceptance of the recommendation, the repair officer requested that EB management review the action recommended by the researchers and either implement it or propose an alternative to accomplish the same end.

The response of EB management was to develop an alternative solution which was approved and implemented over the next month. Fourteen electricians and one chief were reassigned to the Machinery Branch to form a motor repair team within the Pump Shop.

Changes in 38C's Relationship with 31A

Three problems were identified in analysis of 31A's role in the pump repair system: (1) lack of accountability for timely completion of all parts of a job because each part was individually scheduled through the shop; (2) time delays in moving parts between

successive sections within 31A; and (3) lack of any mechanism for tracking all components of a job. To address these problems it was decided to explore the possibility of reorganizing 31A into two product-oriented clusters (pumps and motors; valves and other components), each capable of performing all machining operations for the products they processed.

A collaborative analysis was made of shop inputs (present loading of each 31A section by product source in terms of lead work center) to determine the feasibility of such a reorganization (Figure 5c). It was concluded that the reorganization was possible and desirable to increase identification of workers with the end product, but the task force was divided over the new demands it would place upon the 31A section foremen. The shopmaster, representing the section foremen, expressed strong reservations because the reorganization would have required supervision across the entire range of machining operations as opposed to traditional specialization by machine type.

There was heated debate on this issue during a formal task force meeting. After two hours a consensus was reached to implement on a trial basis a proposal presented by the shopmaster. The work acceptance function in 31A was changed so that each of two shop planners specialized in products originating from certain shops and became responsible for scheduling and tracking the work on all parts related to each product (e.g., pump). This proposal addresses the three problems identified above, but shifts the responsibility and accountability for improvement from section foremen to the planners. So far the change appears to be successful; however, if demands on the pump repair system continue to increase, it might become necessary to reexamine the concept of reorganizing the Machine Shop into product clusters.

Changes in 38C's Relationship with SIMA Planning and Technical Documentation Support Functions

Implementation of changes in pump planning was more complex due to the involvement of many people in the task force problem-solving process. Evaluation of the relationship between the Planning Department and pump repair revealed two important concerns. First, considerable shop production resources were being spent in duplicating Planning Department efforts pertaining to ship checks and the procurement of technical documentation. Second, in cases involving revisions and emergent work, delays of three or four days were common due to centralization of the planning function (Figure 5d).

Recognition of these concerns led the task force to the conclusion that planning after the start of the ship's availability should be decentralized to the shop level. The civilian head of the Planning Department expressed strong reservations about decentralizing any aspect of the planning function. It is possible that such reservations arose partially due to his civil service status which relates scope of responsibility and number of subordinates to pay grade and promotion. After some heated debate during formal task force meetings, a consensus was reached to implement a three-month trial period for shop planners following one month of training. Shop planners became a permanent feature of the pump repair system following the trial period.

Reallocation of Space in Building 3278

Once the task force reached a consensus regarding the changes within 38C, between 38C and its AWCs, and between 38C and SIMA support functions, it became apparent that additional space within building 3278 was needed (Figure 5e). Fortunately, a new building

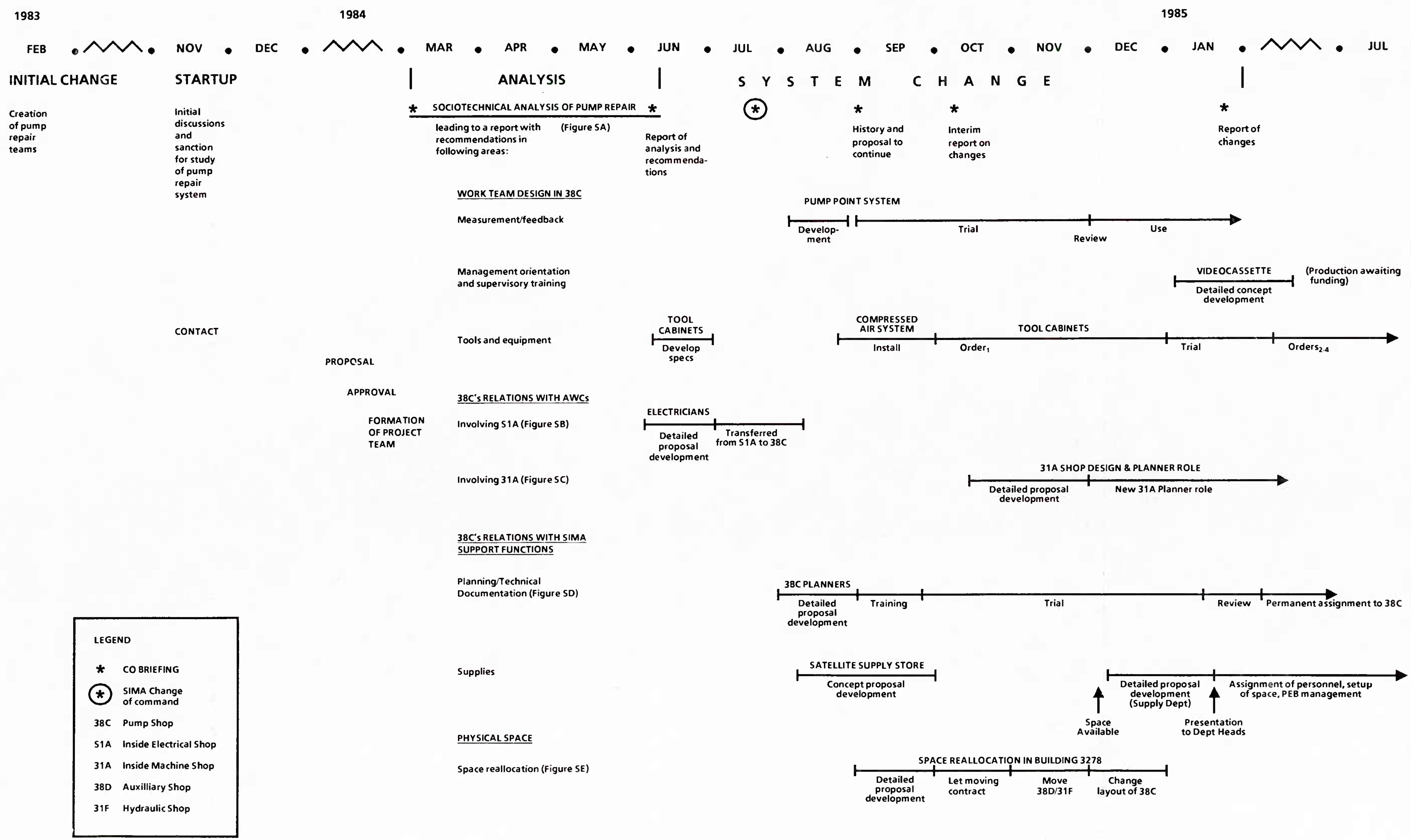

Figure 5. Sociotechnical Design Process for Pump Repair at SIMA San Diego

Informants:

- Executive Officer (XO)
- Management Engineer (ME)
- Production Officer (PO)
- Repair Officer (RO)
- Planning Officer (PLO)
- Pump Planning Supervisor (PPS)
- Central Planners (CP)
- Work Acceptance Officer (WAO)
- Type Desk Officer (TDO)
- Supply Division Officer (SDO)
- Stock Control Supervisor (SCS)
- Customer Service Supervisor (CSS)
- Management Information System Department Director (MIS)
- Machinery Branch Officer (MBO)
- Machinery Division Officer (MDO)
- Pump Shop Documenter (PSD)
- 38C Shopmaster (CM38)
- 38C Floor Supervisors (FS38)
- Pump Team Leaders (PTL)
- Pump Team Members (PTM)
- 31A Shopmaster (CM31A)
- 31M Shopmaster (CM31M)
- Electrical Branch Officer (EBO)
- Electrical Branch Division Officer (EDO)
- Electrical Material Officer (EMO)
- Electrical Section Supervisors (ESS)

Objective: Evaluate suitability of team-based work system design in 38C and identify areas for improvement in the system of pump repair.

Action	Actors	Date	Process issue
Environmental scan and sociotechnical analysis, including:	XO,ME,PO,RO		Develop researcher credibility
Workloading/work acceptance	WAO,TDO,ME	3/84	Initiate collaborative involvement of key players
Planning and technical documentation	PLO, PPS, CP, ME	3/84	
Procurement	SDO, SCS, CSS	3/84	
Management information system	MIS, PPS, PSD, ME	3/84	Develop systems perspective
Sociotechnical analysis of operations within 38C	MBO, PSD, CM38, FS38, PTL, PTM	4/84	
Sociotechnical analysis of work relations between 38C and its primary assist work centers:			Develop shared goal
Electrical Branch (S1A, S1C, 92A)	EBO, EDO, EMO, ESS	4/84	Develop belief in potential for improvement
Other shops in Machinery Branch (31M, 31A)	MBO, MDO, CM31A, CM31M	5/84	
Write up analysis and develop recommendations	Researchers	5/84	Explicit recommendations and rationale
Review	ME, Researchers	5/84	Gain initial reaction; give forewarning of contents
Prepare presentation to CO	Researchers	5/84	
Command presentation	CO, XO, ME, PO, RO, MBO, EBO, Researchers	6/6/84	CO's approval of recommendations; demonstrated sanction for change

Figure 5A. Sociotechnical Design Process: Analysis of System of Pump Repair

Task force participants:

Executive Officer (XO)
Management Engineer (ME)
Production Officer (PO)
Repair Officer (RO)
Machinery Branch Officer (MBO)
Machinery Division Officer (MDO)
38C Shopmaster (CM38)
38C Floor Supervisors (FS38)
Pump Team Leaders (PTL)
Pump Team Members (PTM)
Electrical Branch Officer (EBO)
Electrical Division Officer (EDO)
Electrical Material Officer (EMO)
Selected Enlisted from 51A (ENL)
Researchers (R)

Objective: Enhancement of 38C control over repair of motors from close coupled pumps.

Action	Actors	Date	Process issue
Sociotechnical analysis of Electrical Branch work system design and relationship between 38C (LWC) and 51A (AWC)	EBO, EDO, EMO, ENL, MBO, MDO, CM38, FS38, PTL, PTM, R	4/84	Initiate collaborative involvement of key players
Write up analysis and develop recommendations	R	5/84	Explicit recommendations and rationale
Review	ME, R	5/84	Gain initial reaction; give forewarning of contents
Prepare presentation to CO	R	5/84	
Command presentation	R, CO, XO, ME, PO, RO, MBO, EBO	6/6/84	CO's approval of recommendations; demonstrated sanction for change
Assign responsibility for implementing recommendations	PO, RO, MBO, EBO, EDO EMO, R	6/11/84	Build ownership by locating responsibility in client system
Develop detailed organization design alternative	EBO, EDO, EMO, ENL	6/11-18/84	
Approval	RO, PO	6/25/84	
Implementation in 2 stages (transfer 6 electricians, then 8)	EBO, MBO, ENL	7/1/84 7/23/84	

Figure 5B. Sociotechnical Design Process: Changes in 38C's Relationship with 51A

Task force participants:

- Executive Officer (XO)
- Management Engineer (ME)
- Production Officer (PO)
- Repair Officer (RO)
- Machinery Branch Officer (MBO)
- Machinery Division Officer (MDO)
- 38C Shopmaster (CM38)
- Pump Team Leaders (PTL)
- 31A Shopmaster (CM31)
- 31A Section foremen (SF)
- Equipment Repair Manager (ER)
- Researchers (R)

Objective: Improve coordination in machining assistance by 31A to 38C.

Action	Actors	Date	Process issue
Workload analysis of 31A, by lead work center (pump, valve, hull, electrical, 31A, miscellaneous) and 31A section (lathe, mill, grind/heavy)	R, CM31, ER	10/84	Initiate collaborative involvement of key players
Develop proposal for reorganization of 31A (change from function to product organization)	R, XO, ME, PO, RO, MBO, MDO, CM31, SF, ER	10/84	Build consensus; resisted by 31A supervisors
Task force meeting resulting in revised proposal addressing work acceptance and tracking by 31A planners	R, XO, ME, PO, RO, MBO, MDO, CM31, ER	11/9/84	Build ownership by recognizing shop-level expertise
Inform parties of new 31A planner role and 38C relationships	MDO, CM31, CM38, PTL	11/84	Clarification of new roles and information requirements

Figure 5C. Sociotechnical Design Process: Changes in 38C's Relationship with 31A

Task force participants:

- Executive Officer (XO)
- Management Engineer (ME)
- Planning Officer (PLO)
- Head of Planning (HP)
- Pump Planning Supervisor (PPS)
- Production Officer (PO)
- Repair Officer (RO)
- Electrical Branch Officer (EBO)
- Central Planners (CP)
- Design Engineer (DE)
- Technical Library Supervisor (TLS)
- Machinery Branch Officer (MBO)
- 38C Shopmaster (CM38)
- Researchers (R)

Objective: Improve shop-level control of planning and technical documentation.

Action	Actors	Date	Process issue
Sociotechnical analysis of planning and technical documentation for pump repair	R, XO, ME, PLO, HP, PPS, CP	3-4/84	Initiate collaborative involvement of key players
Write up analysis and develop recommendations	R	5/84	Explicit recommendations and rationale
Review	ME, R	5/84	Gain initial reaction; give forewarning of contents
Prepare presentation to CO	R	5/84	
Command presentation	R, CO, XO, ME, PO, RO, MBO, EBO, PLO, HP, PPS	6/6/84	CO's approval of recommendations; demonstrated sanction for change
Develop detailed proposal for decentralizing pump planning and improving technical documentation support	R, XO, ME, PLO, HP, PPS, CP, DE, TLS	8-9/84	Collaborative problem definition and generation of alternatives
Task Force meeting: Resolution of issues and choice of alternative	R, XO, PO, RO, PLO	9/11/84	Consensus building and command approval for trial
Training, trial, and permanent assignment of planning personnel to 38C	PLO, PPS, CP, MBO, CM38	10/84-2/85	Full responsibility assumed by SIMA management

Figure 5D. Sociotechnical Design Process: Changes in 38C's Relationship with SIMA Planning and Technical Documentation Support Functions

Task force participants:

Executive Officer (XO)
Management Engineer (ME)
Supply Officer (SO)
Production Officer (PO)
Repair Officer (RO)
Planning Officer (PLO)
Head of Planning (HP)
Machinery Branch Officer (MBO)
38C Shopmaster (CM38)
Electrical Branch Officer (EBO)
Facilities Maintenance Engineer (FME)
Equipment Repair Manager (ERM)
Technical Library Supervisor (TLS)
Researchers (R)

Objective: Co-locate pump repair personnel, improve work and storage space, and improve supply support.

Action	Actors	Date	Process issue
Develop detailed proposal for space reallocation in Bldg 3278	XO, ME, SO, PO, RO, MBO, CM38, EBO, FME, ERM, R	9-10/84	Collaborative problem definition and generation of alternatives
Task force meeting resolve issues	ME, SO, PO, RO, EBO, PLO, HP, TLS, FME, ER, CM38, R	10/2/84	Consensus in face of diverse perspectives
Command presentation	CO, XO, ME, PO, RO, PLO, HP, MBO, FME, ERM, R	10/5/84	CO support for task force recommendation; demonstrated sanction for change
Contracting	SIMA procurement	10/84	
Move 31F & 38D from Bldg 3278	Contractor	11/25-12/15/84	
Move personnel & equipment into vacated spaces in Bldg 3278	38C electricians, pump teams, & planners; supply storekeepers	12/10-20/84	

Figure 5E. Sociotechnical Design Process: Reallocation of Space in Bldg 3278

was just being completed in which potentially desirable space was available. Unfortunately, that space was previously designated to other SIMA functions. Ultimately, the task force recommended that some of the new space be redesignated to those shops that should be moved out of building 3278. The task force argued that pump repair is one of the most critical of SIMA operations and, therefore, should take priority over other intended use of the space. The CO concurred and the reallocation of space in building 3278 was carried out.

This decision illustrates an important point regarding planned organization change. It is advantageous if the focus of a planned change is a system of primary importance to the organization. The probability is high that sooner or later changes in that system will lead to competition for scarce resources. In those instances, allocation decisions, if made on rational grounds, will be based on relative priority of the functions being performed.

Time Schedule

The change to a team-based organization in 38C occurred in February 1983. Since evaluation began in March 1984, some recommended changes supporting this major reorganization have likewise been completed, while others are still in progress. A summary of changes and a timetable for accomplishment follow.

	Accomplishment Date
Changes Within 38C	
1. Addition of team performance measurement system which weights pumps according to type, size, and condition.	9/84
Feedback of 2-month moving average to minimize fluctuations.	7/85
2. Training and orientation program for incoming shop-level management and supervisory personnel designed and produced.	1/85 10/85
3. Installation of compressed air system;	9/84
standardized tool cabinets and portable tool boxes supplied to first two teams;	1/85
cabinets and tool boxes supplied to two additional teams per quarter.	4/85, 7/85, 10/85
Changes in Relationship of 38C and its Primary AWCs	
4. Fourteen electricians moved from 51A to 38C to repair close coupled pump motors.	7/84
5. Role of 31A shop planners redefined to comprise scheduling and tracking of work by product, with each planner serving a subset of shops.	12/84

Changes in Relationship of 38C and SIMA Staff Support

		Accomplishment Date
6.	Shop planner position created in 38C for processing revisions and emergent work after the ship's availability period begins.	10/84
7.	38C shop planners given responsibility for obtaining technical documentation and building a shop library of frequently needed manuals and prints.	10/84
8.	Satellite supply store developed in Building 3278 to manage inventory for 51A, 31D, and 38C PEB programs; to provide a point of contact with supply, and store high volume parts and materials for 51A, 31D, and 38C.	 2/85 2/85 6/85

Changes in Physical Space

9.	Relocation of 38D and 31F to Building 3339.	12/84
10.	Reallocation of space on the first deck in Building 3278 to 38C repair teams, electricians, shop planners, Air Compressor Shop and for new equipment and storage; reallocation of space on the second deck to supply, and electrical branch production.	12/84 12/84 6/85

EVALUATION

Data to Date

Table 4 presents the results of the longitudinal analysis comparing productivity before and after the reassignment of electricians to support the work team design in 38C. This change resulted in consistent improvements across all three measures of productivity during the three-month period for which data were available. Given the brief time period and the fact that additional complementary changes were in the process of implementation, the results must be taken as tentative.

Table 4

Evaluation of Complementary Change to Support Work Team Design in the Pump Shop

	Teams Only (N=12 months)	Teams with Electricians (N=3 months)	Change (%)
Pumps completed per month adjusted for manning level	60.3	71.4	+18.4
Mean production efficiency	87.5%	100.3%[a]	+14.6
Mean job efficiency	94.6%	98.3%	+3.9

[a]Over a short time, here three months, it is possible for the production efficiency index to exceed 100 percent. This occurs because documented man-hours are credited at the time the job is completed. Since many jobs are completed in a month different than the one when most labor was expended, the documented man-hours for the month of job initiation may be artifically low, whereas the documented man-hours for the month of job completion may be artifically high. These fluctuations cancel out over time.

Discussion

One can tentatively conclude from the three-month period for which data are available that this action research project is at least maintaining past productivity gains and appears to be improving upon them.

Using sociotechnical analysis, the task force was able to identify and implement complementary changes in organization structure and functioning to support the work team design in 38C. These structural changes were made during a period of unusually high turnover. From July through December 1984, the following critical personnel rotated: five of seven team leaders, the Shopmaster in 38C, the Machinery Branch Officer, the Repair Officer, and key personnel from various AWCs. Their replacements were informed of project scope and goals and included in the task force.

RELATED ISSUES

INSTITUTIONALIZATION

Forces and Equilibrium

Kurt Lewin (1951) conceptualized social system change as progressing in three stages. First, there is unfreezing, where a felt need for change translates into a change-receptive attitude on the part of organization members. This is followed by the change itself, represented here by the case study. Finally, there is refreezing or quasi-stationary equilibrium, reached after the changes are implemented and the new system of organization becomes the norm. The process of change does not end with implementation of changes; there are driving and resisting forces or pressures operating which have an impact on the potential institutionalization of the new system design.

Forces Operating in Military Settings

There are pressures associated with the civilian-military mix of personnel in a given organization. In settings characterized by a high percentage of military personnel, such as in IMAs, resistance to change is minimal. On the other hand, the forces countering institutionalization of changes in such organizations may be powerful. One example is the high planned turnover rate which acts to reduce retention of organizational learning and knowledge at the same time as it brings in replacement managers and supervisors with a propensity to make their mark by implementing changes during their tours of duty.

The opposite effect may occur in organizations with a high percentage of civilian personnel. As discussed earlier, territorial issues might result in a high level of resistance to the introduction of change because of a perceived threat to job security. Once change has been implemented, however, the new system is likely to receive strong support for institutionalization because of long-term corporate memory and employee "ownership" of changes which have been introduced.

Other Forces Affecting Change in Military Settings

There are other forces that can affect the longevity of organizational change regardless of the civilian-military mix. These forces can be categorized as: (1) organizational, (2) individual, (3) technological, and (4) environmental.

Organizational Forces

The sociotechnical model of organization has its roots in open systems theory. The organization is viewed as interacting with its environment. Its subsystems transform inputs from the environment into products or services for the environment. This concept has implications for institutionalizing change. Other functionally-related subsystems in the organization must be redesigned to complement any new work system. Complementary change is necessary to avoid impairment of team functioning due to lack of control by team members of resources required to accomplish their goal. This impairment can lead to frustration and the misconception that the team-based design is the cause of any problems. This sense of failure can result in implementation of other changes which may interrupt or end the institutionalization process.

Prior to reassignment of electricians from the EB to the Pump Shop, pump team members had no control over repair of motors for close coupled pumps. By reassignment of electricians to the Pump Shop and concomitant changes in other AWCs and staff support functions, organizational subsystems which previously limited pump team control and operation became more complementary to the functioning of the team-based organization. These changes highlighted for all participants in the pump repair system their contributions to goal accomplishment. What has emerged is a shift in organizational culture from task and function identification to a product-oriented system perspective. Maturation of this new culture and continued success of the team-based system of pump repair will contribute to establishing a new norm for pump repair, thereby helping to institutionalize the organization redesign.

Individual Forces

Development of a supportive culture is an important factor in the institutionalization process. The complementary structural changes which created an integrated system of pump repair played an important role in developing a new culture. Culture, however,

must also be passed to later generations of organization members if it is to survive. This becomes critical in Navy-manned organizations where planned rates of personnel turnover are extremely high. Overcoming the effects of high turnover, which exerts a resisting force on cultural maturity, requires support from all organization members involved in the redesigned system.

The CO plays a crucial role. It is necessary for the CO to exhibit full support for the emerging culture and to take steps to share its importance and fragility with his or her replacement. Unless the incoming CO is aware of and sensitive to the importance of his support of the emerging culture, institutionalization of organizational changes might be critically slowed or even reversed.

Other organization members also play important roles in maintaining the health of the new system. Managerial and supervisory roles have changed with the shift to team-based organization. These roles have become more facilitative, performing an integrative rather than an overseer function. This may appear new, perhaps strange, to incoming replacements. Unless incoming managerial and supervisory personnel understand the history and functioning of the new system they are apt to falter in fulfilling their roles. This lack of appreciation of their new roles can result in their introduction of minor changes within their domain of responsibility which could seriously affect the team-based system of organization. In the present case, this area is being addressed through development of an orientation and training program for incoming managers and supervisors. Incoming personnel will be given an orientation to the history of the changes, why they were made, present system functioning, its demonstrated success, and the role they must play to maintain the system design.

Team members also have an important role in institutionalizing team-based organization. So long as team members see the effectiveness and efficiency of the new work system design and understand the importance of their contribution, they are apt to work in a manner which perpetuates its success. Emery (1972) noted that, based on prior experience in sociotechnical system design, it was possible to identify aspects of "good work" that lead to high levels of commitment and performance. These include challenge and variety as well as the ability to complete a whole task, receive feedback, and recognize the importance of one's contribution. These same factors were identified by Hackman and Oldham (1976) as measurable characteristics of jobs which should be present at appropriate levels to foster employee motivation and performance.

In the present case, the team-based design incorporates all of the important features associated with high levels of morale, commitment, and motivation. Team members experience a reasonably high level of challenge and task variety while taking total responsibility for the repair of a pump. The feedback system gives teams timely information on their performance in comparison to similar groups. Furthermore, the culture now explicitly recognizes the critical importance of pump repair to the Fleet and the value of each member's contribution.

Technological Forces

Technology is another factor which plays an important role in institutionalizing the redesign. Decisions are continually required regarding changes in technology. These decisions, whether involving reallocation of equipment within the shop or across shops, reallocation of physical space, or procurement of new equipment, should take into account effects on the organization and its functioning.

In the pump repair system this is exemplified in a number of ways. The design, test, and procurement of a custom tool cabinet for each pump team requires a larger capital investment than a smaller number of tools dispensed from a centralized tool crib under a controlled checkout system. However, the time saved in inventory control will have direct payoff in production, more than offsetting any cost, while supporting the team design by enabling each team to have control over the equipment it needs to accomplish its goals. The electroplating equipment, which is presently located in the EB, will soon be redistributed. When the necessary ventilation and plumbing modifications have been made in the Metal Buildup Shop, a portion of the electroplating equipment sufficient to support pump repair operations will be reallocated to the Machinery Branch, placing this assist function under the control of the pump repair system. The reallocation of physical space is another example of how changes related to technology can be made to support the new system of organization.

The effect of future changes in technology can either support or undermine the process of institutionalization. SIMA will soon face important decisions in this respect as it plans for a new computer system. Computer technology tends to be viewed as facilitating centralized decision-making. If organizational functioning became more centralized it might so disrupt team functioning as to subvert institutionalization of the team-based organization design. Modern computer technology, however, possesses extreme flexibility in how it can be used. So long as decisions regarding the purchase and use of hardware and software recognize that the system of pump repair requires timely distribution of information necessary for self-management, the technology can further support institutionalization of team-based organization.

Environmental Forces

The environment also plays a key role in institutionalization of organization change. SIMA, San Diego is not a self-contained organization. It is nested in a complex Navy organization which includes Naval Sea Systems Command (NAVSEASYSCOM), COMNAVSURFPAC, and the Fleet. These supra-organizations exert important forces on SIMA and thereby critically influence institutionalization. Both NAVSEASYSCOM and COMNAVSURFPAC develop and administer policies and procedures which impact on SIMA functioning. If these policies and procedures contain elements which force SIMA to operate in ways which are contradictory to the requirements of the system of pump repair, the institutionalization process could be halted.

A critical procedure is the scheduling of ships into SIMA for repair. Scheduling decisions are presently based on operational requirements of the Fleet without consideration of their impact on the workload of SIMA. The net effect is a turbulent environment for SIMA, with random shifts from peak to lull periods and back again. This presents a serious problem for any system of organization, including the system of pump repair at SIMA. During lull periods it is very difficult, if not impossible, for SIMA to adjust its personnel. This results in production workers being underutilized, unchallenged, and from the SIMA's point of view, unproductive. If a lull occurs during a period in which a large number of key personnel turn over, there can easily develop a lack of recognition of the purpose for the team-based design and, thereby, a tendency for new personnel to make changes in their domain of responsibility toward more traditional Navy forms of organization. Even seemingly small changes made under such conditions can seriously alter the relationships among interdependent parts of the system and thereby deinstitutionalize the new system of organization.

The opposite side of the coin can have equally devastating effects. Peak periods can result in such extensive overloading that no system of organization could effectively operate to meet the demand. This can result in high levels of frustration, perceived failure, and an attribution of blame to the work system rather than the environment. Key personnel might perceive that the system is failing, which in such a case would only be a symptom, not a cause, of the problem. Thus, local change efforts, such as the pump repair system of SIMA, San Diego, may require adjustments in macro-level policies and procedures to support their continued functioning over time.

In summary, the change process must be understood by all concerned as a dynamic process continuing beyond implementation. Changes must be institutionalized in an environment made up of conflicting forces. In the present case we have identified four types of forces whose net effect can either support or subvert institutionalization. So long as decisions regarding organization functioning, individual member behavior, the procurement, allocation and use of technology, and policies and procedures continue to complement the new system design, the probability of the design's long-term viability will be enhanced.

Redesign represents a quasi-stationary equilibrium rather than a permanent state. The sociotechnical principle of incompletion addresses organization design as an on-going process. There will always be changes brought about by the four types of forces identified above. It becomes the responsibility of the organization members to incorporate changes in a manner consistent with the objectives of the existing design to insure its viability.

TRANSFER ISSUES

Further development and application of sociotechnical system design in the Navy requires the transfer of successful innovations from the initial, trial setting at SIMA, San Diego to other organizations and systems. Unlike many "canned" programs, the outcome of a sociotechnical system design process does not consist of a universal solution which is repeatedly implemented in various new settings. Sociotechnical system design is a technology consisting of a method of analysis and problem solving applicable to a variety of settings. If the methodology is carried out appropriately in a new setting, insights into necessary changes can be achieved and changes implemented in a manner likely to be successful. In the use of sociotechnical system design, the issue of transferability must be understood in terms of transferring a method, not a solution, from one setting to another. Successful transfer of the sociotechnical system design method is influenced by a number of factors, including: (1) characteristics of the client system, (2) the focus of the change efforts, and (3) the purpose of the change efforts.

Characteristics of the Client System

A number of prerequisites should be met for successful application of sociotechnical system design. There must be a strong felt need for change on the part of key organization members and strong sanctioning support from top management to pursue a sociotechnical system design process. This implies a consensus on the part of top management to pursue long-term planned organizational change as opposed to short-term crisis management. The consensus is critically important, because the sociotechnical system design process involves collaboration of key organization members with the change agents (in this case, the researchers) regarding problem definition, analysis and evaluation of present system functioning, recommendations for change, and implementation. This requires strong commitment and a high level of involvement on the part of key personnel which can only be engendered by top management sanction. Lastly, it is important that

the system under analysis have strong relevance to the organizational mission. If this is true, the value of success can be seen as offsetting the time, energy, and costs incurred.

Focus of the Change Efforts

The focus of change is important to the transfer of sociotechnical system design. Different intervention strategies focus on different aspects of organizational functioning. The focus of sociotechnical system design is "technostructural," as opposed to "human processual," in nature. A basic assumption of the sociotechnical system design method is that interpersonal processes are symptoms of causes deep-rooted in the structural design of the organization.

The information collection stage of a sociotechnical analysis will usually uncover conflict, poor communication, and poor leadership patterns. These symptoms were evident in the relations between the management and supervision of the Electrical and Machinery Branches in the repair of close coupled pumps. The sociotechnical approach, however, did not attempt to treat the symptoms through organizational development interventions such as conflict management or team building. From the sociotechnical system design perspective, the poor human relations were symptoms of poor structural design, requiring structural changes to remove the causes. Moving electricians from the EB to the Machinery Branch, giving the Pump Shop control of activities required for repair of close coupled pump motors, eliminated the source of the conflict as well as the basis for poor communication and leadership. By removing these obstacles, it was possible for relations to normalize between the two branches.

Purpose of the Change Efforts

The last issue concerning transfer of the sociotechnical system design method is the purpose of the intervention. Often analysis reveals that a particular system is inhibited from effectively accomplishing its goal due to structural constraints. The purpose of sociotechnical analysis is to identify such constraints and to generate recommendations which can ameliorate the problem. The goal of sociotechnical analysis from a design perspective is to identify and develop within the system under investigation team members who possess control of the resources necessary to be self-managing in accomplishing a whole and identifiable piece of work.

This "whole piece of work" may be simple to identify in blue collar settings, such as a pump that needs repair. In white collar service organizations identification of the whole piece of work may be more subtle, but it can usually be defined. Thus, the sociotechnical system design process can be applied in white collar settings where the present system of information or paper processing is fractionated by task or function yet still amenable to redesign. The central issue here is that key organization members not allow past territorial and ownership concerns to interfere with redesign undertaken to solve important productivity problems.

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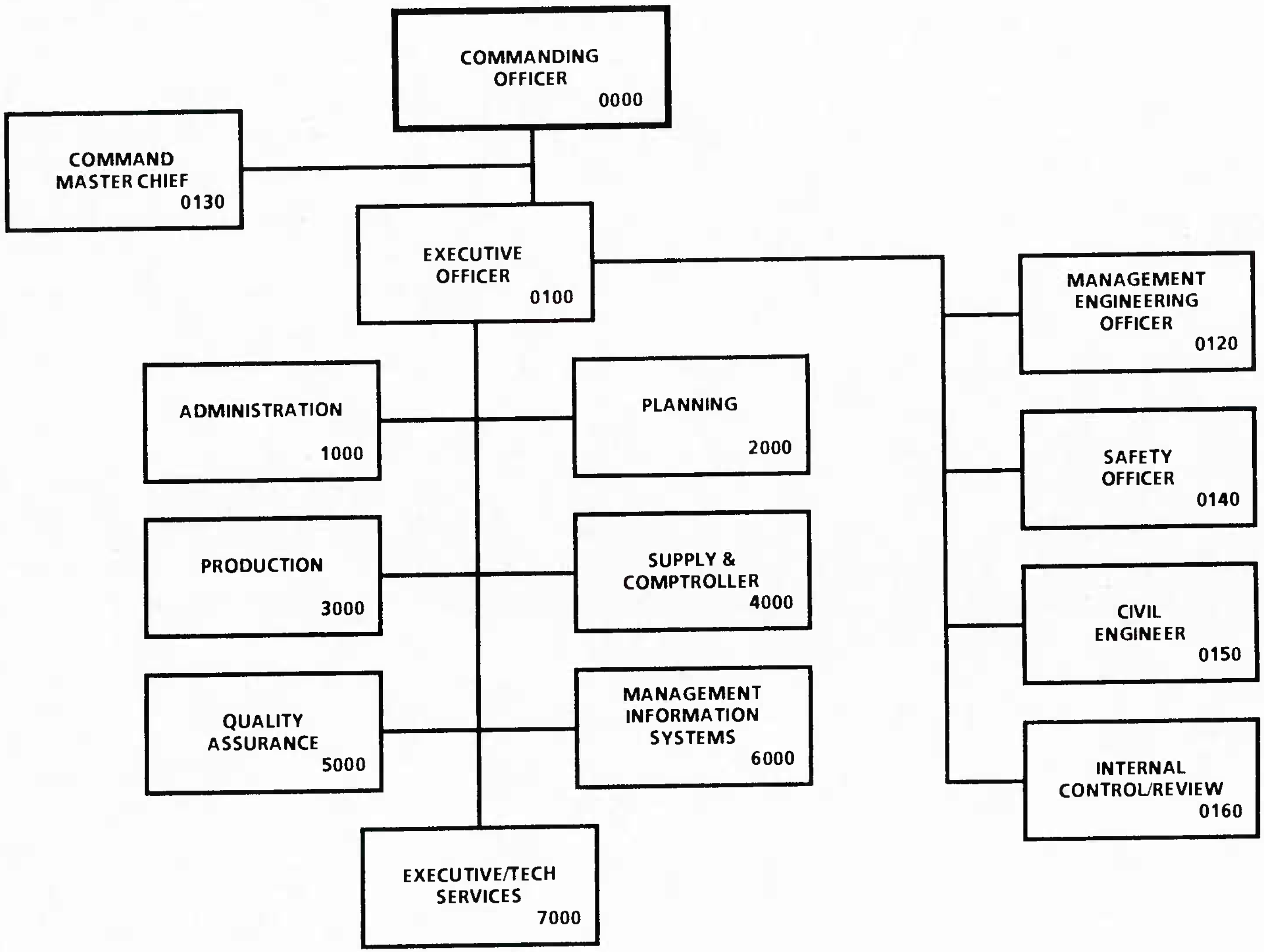
APPENDIX A

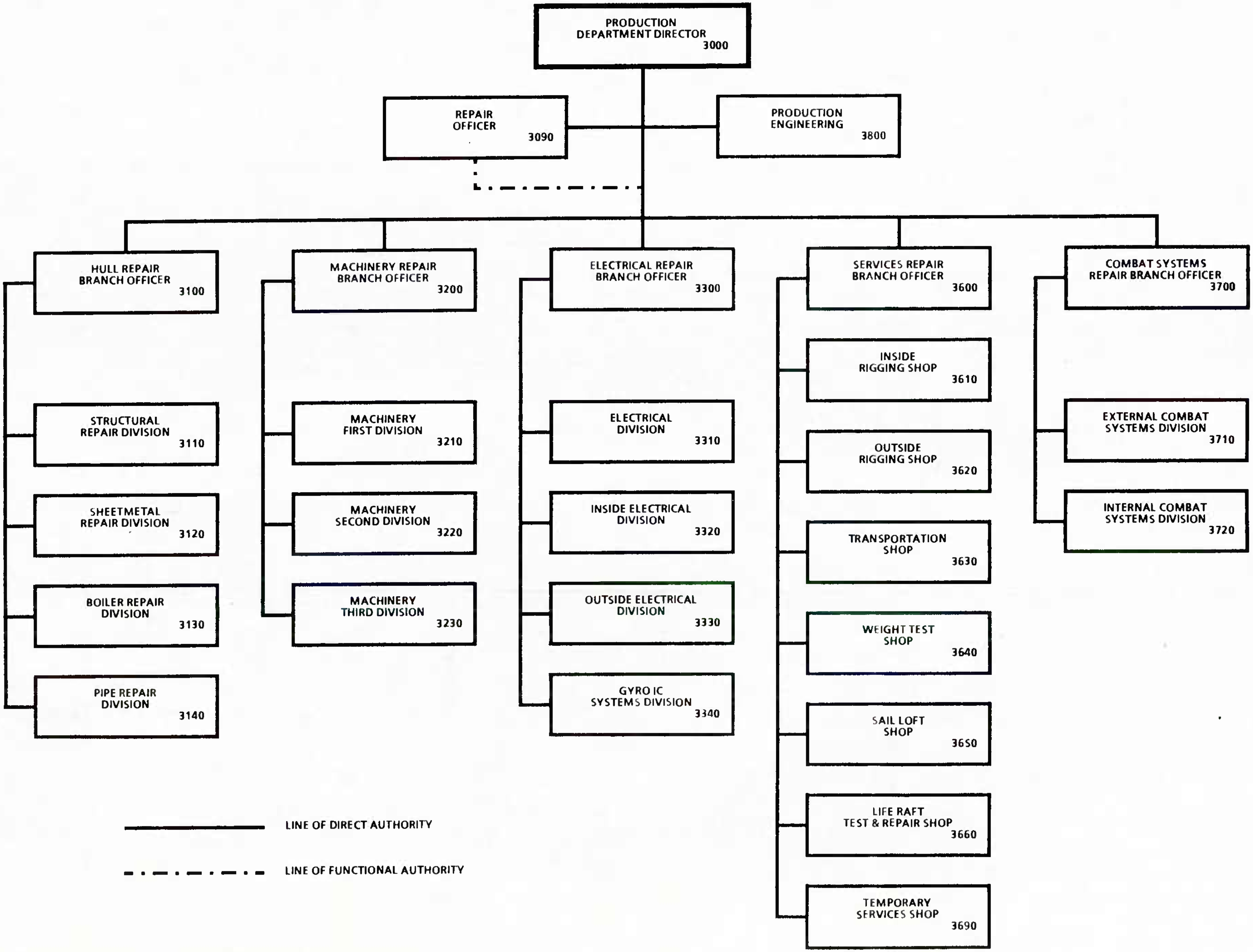
ORGANIZATION CHART OF SIMA, SAN DIEGO: FOCUS ON THE PUMP REPAIR SYSTEM

ORGANIZATION CHART OF SIMA SAN DIEGO: FOCUS ON THE PUMP REPAIR SYSTEM

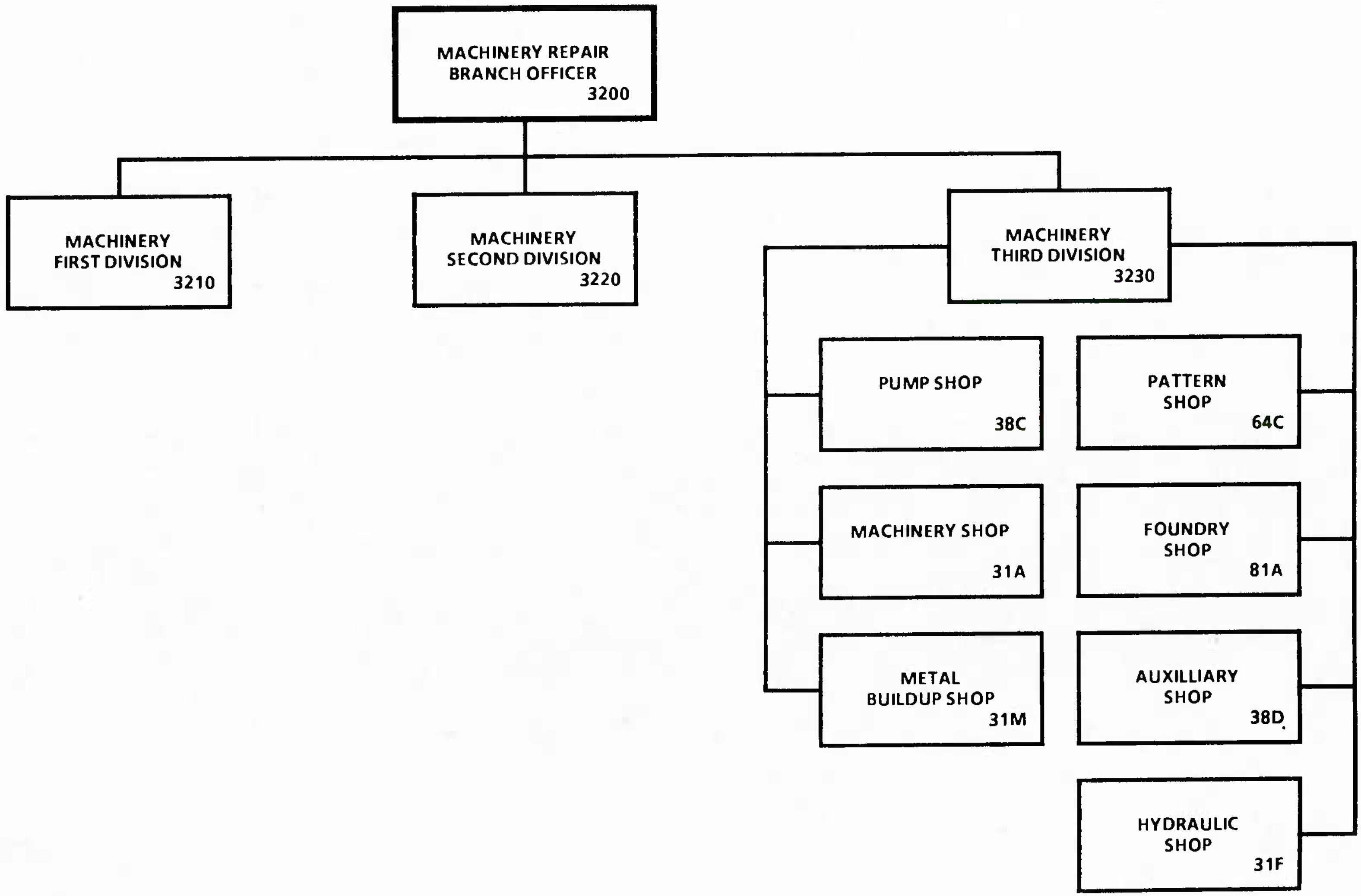
1. Macro Level Departmentation



2. Organization of the Production Department

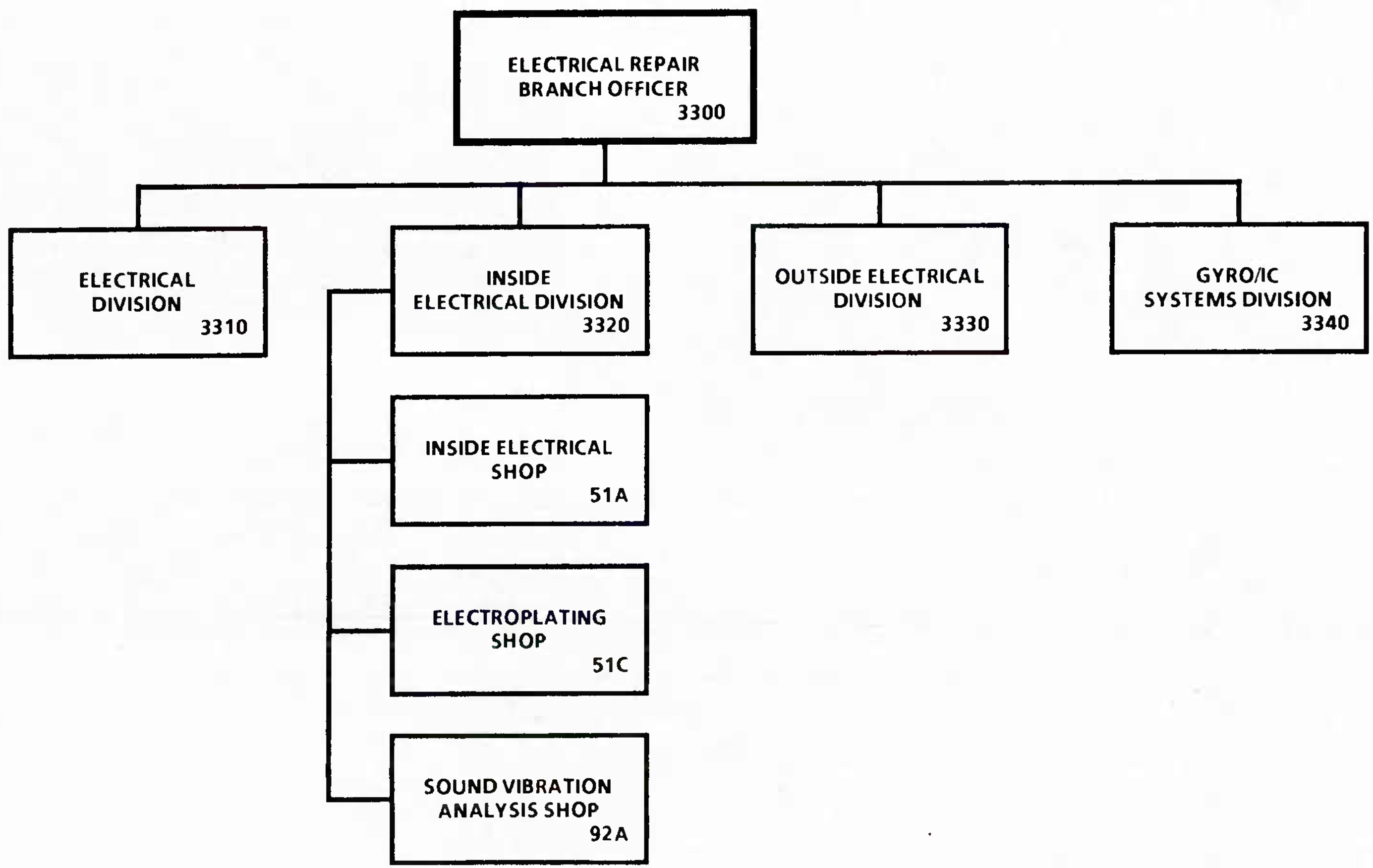


3. Organization of the Machinery Branch[1]



[1] Prior to the implementation phase for changes in the pump repair system 31A and 31M were located in the first division, 64C & 81A were in Hull Branch, and 31F was in second division

4. Organization of the Electrical Branch



APPENDIX B

ORIENTATION AND TRAINING PROGRAM FOR 38C:
PROPOSED OUTLINE FOR VIDEO CASSETTE

ORIENTATION AND TRAINING PROGRAM FOR 38C: PROPOSED OUTLINE FOR VIDEO CASSETTE

I. History.

A. Structure and functioning of 38C prior to the "team concept" (chart).

1. Two 15-20 person teams with specialized skills: (a) disassembly (sometimes including removal, (b) reassembly (sometimes including reinstallation).

2. Assignment of current work to personnel on the basis of availability at the moment; hence, little identification with the product or accountability for work performed.

B. Reasons for change.

1. High rework and customer dissatisfaction over quality of repairs.

2. Inadequate quantity.

3. Poor schedule adherence.

C. Present structure and functioning of 38C (chart).

1. Multiple teams, each with responsibility for entire repair job on pumps assigned, including their removal and replacement.

2. Shop, Branch and SIMA resources organized to support pump teams.

D. Data on success of new design.

1. Pumps completed.

2. Production/job efficiency.

3. Other (management judgments): quality/rework; identification/responsibility/accountability; customer satisfaction; top management satisfaction.

E. Summary: 38C's team-based design has been effective in meeting the demand for repair of pumps. It is important that every member of 38C understand how it functions, what its goals are, and how each new member is critical to its continuing success. Though successful, 38C cannot operate by itself; hence, it is important to understand its relationships with the rest of SIMA.

II. Overview of the Pump Repair Process.

A. SIMA support.

1. Work acceptance (SURFAC Maintenance Control Center-->SIMA Work Acceptance Officer-->Type Desk Officer).

E. Recordkeeping.

1. By team--log of progress on each job; tracking completion dates for parts from AWCs.

2. By shop planners--parts ordered.

3. By shop management--hot (high priority) jobs, labor hours, team performance, management information system.

F. Performance feedback.

1. Number of completed pumps.

2. Weighted production counts (pump points).

IV. Key roles within the Pump Repair Shop.

A. Team leaders: provide technical supervision, coordination with AWCs, and schedule team activity.

B. Troubleshooters: provide on-call technical expertise to pump teams.

C. Shop planners: provide planning (including shipchecks), technical documentation, and procurement support to pump repair teams.

D. Documenter: checks accuracy and completeness of job orders; assigns jobs to teams; submits record of man-hours on each job to ADP (including overtime); provides performance feedback to teams.

E. Shopmaster: provides technical supervision and administrative support; serves as an interface with Machinery Branch management and SIMA.

F. Division Officer: provide administrative and management support.

G. Branch Officer: serves as an interface with SIMA line and staff.

D. Reassembly and testing by pump team.

1. Gathering of required parts and components from Supply and AWCs.

2. Reassembly of pump.

3. Quality assurance inspection.

4. Pressure testing.

E. Delivery and reinstallation of pump.

1. Scheduling of ship access, transportation, craning, and rigging.

2. Mounting and hook-up.

3. Operational test.

III. Pump team structure and dynamics.

A. Team size and composition.

B. Work assignment.

1. Key concept: Develop multiple, comprehensive skills in each team member and depth within each team and among teams for task accomplishment.

2. Goal: Feeling of identification with each successfully completed pump; feeling of responsibility for workmanship; accountability within climate of concern for quality and quantity.

C. Leadership and supervision.

1. Coordination, liaison, and planning.

2. Technical (repair knowledge and skills).

3. Production oversight.

D. Training.

1. On-the-job training/apprenticeship.

2. In-house, e.g., by equipment maintenance engineer.

3. SQIP (Shop Qualification Improvement Program).

4. Schools.

E. Recordkeeping.

1. By team--log of progress on each job; tracking completion dates for parts from AWCs.

2. By shop planners--parts ordered.

3. By shop management--hot (high priority) jobs, labor hours, team performance, management information system.

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